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Strain 19 Vaccine in the Control of Contagious Abortion.

C. R. Toop, Asst. Chief Veterinary Surgeon.

EARLY this year Strain 19 vaccine became available for the control of contagious abortion in cattle and a scheme for the use of this product in dairy herds was outlined by this Department. Since that time a large number of heifers have been vaccinated by Departmental Officers in the dairying districts throughout the State and the work is still continuing.

Observations in other countries notably the United States and New Zealand where Strain 19 vaccine has been extensively used in the field for a number of years, have amply demonstrated the ability of this product to greatly reduce the abortion rate and so reduce the wastage caused by the disease. Since there is no reason to doubt that similar results will not be obtained in this country, the use of Strain 19 vaccine may be strongly recommended and it is hoped that dairy farmers will freely avail themselves of the advantages which it offers. As a background to a discussion upon the use of this vaccine it is perhaps advisable to mention briefly some of the more salient features of the disease which should lead to a better understanding of the problems presented by its control.

Its importance cannot be over-emphasised. It is widely distributed throughout the dairying areas of the State and a considerable proportion of the herds are infected. As a source of loss to the industry it is second only in importance to mastitis. It is responsible not only for the loss of the calf but for a considerable reduction of milk yield which has been estimated at from 25 to 30 per cent. In addition sterility resulting from metritis or inflamation of the uterus and retention of the afterbirth frequently occurs as a sequel to the disease. Sterility may become a serious problem in the herd and, unless steps are taken to overcome it by appropriate veterinary treatment, may result in the culling of many valuable animals.

Contagious abortion results from infection with a micro-organism known as *Brucella abortus* which invades the pregnant uterus setting up an inflammatory reaction which causes the death and premature expulsion of the calf. The majority of abortions occur between the 5th and 7th months but the calf may be lost as early as the third or as late as the 8th month of pregnancy.

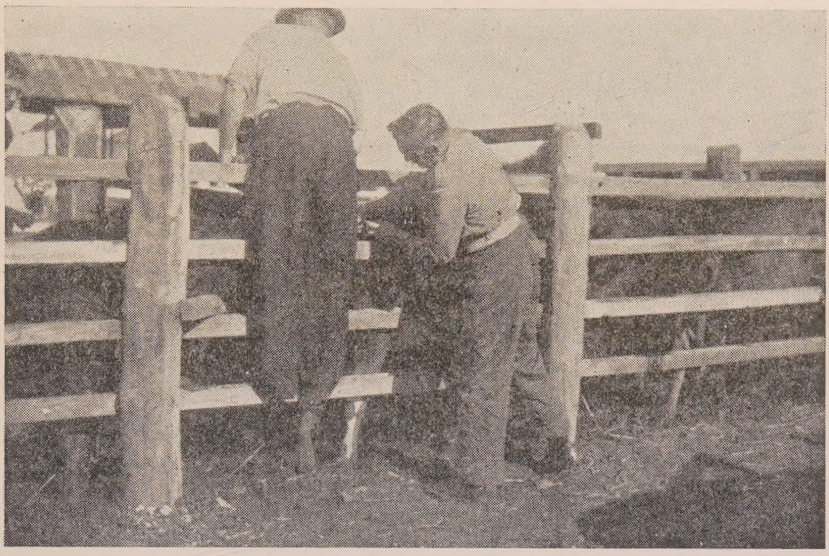
The disease is spread by the fluids which are discharged from the uterus at the time of abortion, by the aborted calf and afterbirth, and by the discharges passed out by the cow for several weeks after abortion has occurred. All of these discharges contain enormous numbers of the Brucella organisms which contaminate the pastures and are picked up by other cattle while grazing. Similarly the disease may be spread by infected cattle which do not abort but which pass out infective discharges following normal calving. In this connection it should be recognised that all cows which become infected do not abort and that the majority of cows that have aborted once do not abort a second time. Such animals are, however, potentially dangerous. They usually remain infected and are carriers of the disease, contaminating the pastures by the discharges voided at the time of calving. All of the available evidence indicates that the bull plays little or no part in the dissemination of the disease. In the great majority of cases contagious abortion is introduced on to a property by the purchase of infected cows or heifers. Consequently in herds which have to rely upon the purchase of female stock for replacements, a serious risk of introducing the disease is always present.

When the disease is introduced into a clean herd it frequently runs an acute course resulting in a large number of abortions which may occur in rapid succession giving rise to the well known abortion storm. After a season or two the disease usually subsides and a stage is reached in which fewer abortions occur and these are principally confined to heifers and young cows. As a result of exposure to infection the majority of the older members of the herd have developed an immunity or resistance to the disease and are able to carry their calves to full term. No such immunity is enjoyed by heifers and young cows and for the protection of such animals Strain 19 vaccine will be found of especial value.

Other Methods of Control Inadequate.—Prior to the advent of Strain 19 vaccine the means which had been available for the control of the disease could neither be regarded as highly effective nor economically sound. The application of hygienic measures had always been advocated and had to a greater or lesser degree been practised by the dairy farmer. They have involved the destruction of the aborted calf and its membranes by burning or deep burial together with the application of a liberal dressing of quicklime to the surrounding area and the strict isolation of the aborting cow for 3-4 weeks until all discharges have ceased. While such measures when thoroughly applied may, and do check the spread of infection, it is obvious that they have not provided an effective means of controlling the disease. Hygienic measures should not, however, be neglected and this remark will apply with equal force even when the vaccination of the heifers in the herd with Strain 19 vaccine is being practised.

Under West Australian conditions there has been little scope for the test and slaughter method of control which is based upon a blood test known as the agglutination test. All members of the herd six months old and over are tested at monthly intervals and all animals giving a positive reaction are removed for immediate slaughter. The process is continued until two consecutive completely negative tests are obtained when the herd is declared abortion-free and is thereafter tested annually. While the advantages to be gained from the eradication of the disease by this method are obvious, being reflected by an increase in the number of viable calves, increased production and greater breeding efficiency, it is an extremely costly procedure and under our conditions must generally be regarded as impracticable, wasteful and economically unsound. For the most part its application could only be advocated

in well isolated herds in which the incidence of infection is low and which do not have to rely upon the purchase of cows or heifers from an outside source for replacement. It must further be recognised that the abortion-free herd is composed of highly susceptible animals and should the infection be re-introduced heavy losses would be likely to occur. There are few herds, however, in which the requirements set out above could be fulfilled.



Inoculating heifers with Strain 19 Vaccine.

IMMUNISATION WITH STRAIN 19 VACCINE.

This brings us to a consideration of Strain 19 vaccine and in view of the inadequacy of other methods of control it is fortunate that we now have in this product a weapon with which to fight the disease. For this product we are indebted to the American workers, Buck and Cotton, who during the course of their investigations were able to isolate a strain of *brucella abortus* of low virulence which we now know as Strain 19. This strain when injected into calves does not cause permanent infection or subsequent abortion and cannot be transmitted from one animal to another. It does, however, confer upon the treated animal a considerable degree of immunity or protection which enables it to resist infection when subsequently exposed.

Results in Other Countries.—In their early experiments these American workers vaccinated 70 calves 4-8 months old with Strain 19, keeping 73 unvaccinated calves as controls. These calves were subsequently mated and when pregnancy was well established, were submitted to a severe exposure test by instilling a few drops of culture of virulent Brucella organisms into the conjunctival sac of the eye. This infective dose would contain about 100,000,000 virulent organisms. In the 70 vaccinated animals only 4.3 per cent. of abortions occurred while in the unvaccinated controls the abortion rate was 73.5 per cent. This work was followed by extensive field trials. In one series involving 8,132 cattle vaccinated as calves and kept under observation for three pregnancies, 96.2 per cent. of the calvings were normal while only 3.8 per cent. of abortions occurred and less

than half of these resulted from Brucella infection. In 1941 Strain 19 was obtained from the U.S.A. by the Department of Agriculture, New Zealand, and similar observations were made. Fifteen heifer calves were vaccinated with Strain 19 and 15 unvaccinated calves were run with them as controls. When pregnant these heifers were subjected to an exposure test as the result of which nine of the unvaccinated animals aborted but only two abortions due to Brucella infection occurred in the vaccinated group. Concurrently large scale field trials in heavily infected herds were conducted. During 1942, 465 heifers were vaccinated and less than 5 per cent. of them subsequently aborted, whereas among 420 unvaccinated heifers running in the same group of herds during the previous year the abortion rate was 32 per cent. Amongst 293 of these vaccinated heifers which were under observation during their second pregnancy only four (1.4 per cent) abortions occurred. In 1943, 10,725 heifers were vaccinated and only 3 per cent. of them subsequently aborted. Twenty-two per cent. of the unvaccinated heifers in the same herds had aborted during the previous year.

Strain 19 vaccine is now being extensively employed for the control of contagious abortion in New Zealand. During 1944, 43,000 heifers were vaccinated and a further 107,000 were treated in 1945. In Victoria a total of 30,000 cattle had been vaccinated up to March 1st of the present year and the information made available indicated that the abortion rate in heifers in infected herds had been reduced from 26.4 to 5.2 per cent. In Great Britain 200,000 heifers were vaccinated during 1945.

These figures provide very convincing evidence of the ability of Strain 19 vaccine to control the disease and of the confidence of dairy farmers in the use of this product. In view of this evidence and the widespread distribution of contagious abortion, the widest possible use of Strain 19 vaccine in Western Australia is strongly recommended.

Facilities for Handling Cattle must be Provided.—For its part, this Department will undertake the vaccination of heifers throughout the dairying areas and is prepared to make officers available to carry out this work. A fee of 1/3 per head will be charged in order to defray the cost of the vaccine and the ear tags used for identification purposes. In order that the scheme may be successful the fullest co-operation on the part of dairy farmers will be necessary and it is requested that wherever possible vaccination centres be established to which the heifers from surrounding properties can be brought for treatment. It should be possible for a group of farmers working together to provide a well constructed crush and assistance of this kind will greatly facilitate the work of Departmental Officers and will considerably increase the number of heifers it will be possible to vaccinate. Without a crush the handling of heifers is a slow and difficult procedure. A crush 15-30 feet long (according to the number of cattle to be treated) with a space of about 8 inches between the rails, 4 feet 6 inches high and 20 inches wide provided with a forcing pen at the entrance and an exit gate for the release of the cattle after treatment, will meet requirements. Whatever type of crush is employed it should be strongly constructed in order that the cattle may be adequately restrained during treatment. Where the circumstances do not permit of heifers being brought to a vaccination centre, individual properties will be visited but it is emphasised that proper facilities for the handling of the cattle must in all instances be provided.

Vaccination of Heifers.—Heifers from the age of six months up to the time of mating may be vaccinated but it will probably be found most convenient, as the work proceeds, to vaccinate them annually as yearlings rather than as calves and there is reason to believe that better results will be obtained from treatment at this later age.

The information at present available indicates that the vaccination of heifers confers a high degree of protection for at least two pregnancies. It is reasonable, however, to expect that the immunity will weaken with the passage of time and more recent American work suggests that the protection obtained from the vaccine may be lost after the third pregnancy. Confirmatory evidence however, will be necessary before a definite pronouncement can be made upon this aspect of the matter.

Adult Cattle.—While a similar degree of protection may be obtained from the vaccination of adult cattle such work cannot generally be undertaken by Departmental Officers. The vaccination of the adult herd presents many problems. In the first place it is desirable that cows should be vaccinated while non-pregnant and this would necessitate a number of return visits to each property before the treatment of the whole herd could be completed. While vaccination in early pregnancy is unlikely to produce serious effects, abortion may occur if the pregnancy is advanced. Moreover, in herds in which the disease has existed for a long period, the abortion rate in the older cows is usually low and no great advantage could be anticipated from the vaccination of such animals. In the case of cows which have aborted or those which have already become infected (and many such animals are detected when the agglutination test is applied to infected herds) vaccination will not serve a useful purpose; neither could it be expected to check the progress of an abortion storm. On the other hand in herds in which perhaps one or two abortions have occurred and in which the disease is just commencing to gain a foothold, vaccination of the adult cattle would prove of the greatest value. Each herd however, would require to be dealt with on its merits and the action decided upon would largely depend upon the previous history of abortion in the herd.

Annual Vaccination.—There are no such problems with regard to heifers and it is considered with the small resources at our disposal that greatest benefit will be obtained by concentrating our attention on animals of this age. If we are able to devote the whole of our energies to the treatment of heifers this will enable a very large number to be vaccinated annually and within the space of a few years the herds participating in the scheme will be largely composed of immunised cattle and the menace of contagious abortion should thereby be correspondingly reduced. It is emphasised that the vaccination of heifers must be regarded as a long range project to be repeated annually if maximum benefits are to be obtained.

The vaccination of heifers is recommended both in clean and infected herds. The advantages to be obtained in the case of the infected herd are obvious and need not be emphasised. In the clean herd the procedure is equally sound and the vaccinated animals will be in a condition to resist the disease should infection be inadvertently introduced. The use of Strain 19 in a clean herd cannot result in the introduction of disease and the fears which are sometimes expressed by stock owners in this connection are groundless.

Effects of Vaccination.—Following vaccination a swelling develops at the site of inoculation. This gradually subsides but a period of several months may elapse before it finally disappears. This is accompanied by a systemic reaction during

which the animal becomes rather tucked-up in appearance and the appetite is reduced. The reaction is however, transient and subsides within a few days. In the case of cows there is usually a sharp decline (25-30 per cent.) in milk yield which sets in within 48 hours of vaccination and persists for about a week before a return to full production occurs.

Cattle vaccinated with Strain 19 develop a positive reaction to the agglutination test which cannot be differentiated from the reaction resulting from natural infection. In the case of calves these reactions subside fairly rapidly and all but about 5 per cent. of them become negative within 12 months. In adult cattle, however, the reaction persists for a much longer period. Under our conditions however, the development of a positive blood reaction is of little consequence. The principal consideration is that the abortion rate shall be reduced and the losses from the disease prevented. The persistence of a positive blood reaction is only likely to be of importance in the case of cattle which are intended for export to other States and countries and are required to be accompanied by a negative agglutination test certificate.

Application for Vaccination.—Owners desiring to participate in the scheme for the immunisation of heifers against contagious abortion are advised to make application to this Department. Application forms upon which it will be necessary to furnish particulars of the herd and of the previous history of abortion, will be provided. These should be completed and returned either direct to the Department or through a local farmers' organisation which has undertaken to make arrangements for the vaccination of cattle in the district concerned. Valuable assistance in this direction particularly with regard to the establishment of well equipped vaccination centres and the provision of manpower for the handling of the cattle, has already been rendered by a number of these organisations. Co-operative efforts of this kind have proved much more effective in dealing with the position than by visits to individual properties and similar action is urged in all districts where the vaccination of heifers from a number of properties is contemplated.

New Cereal Varieties in Australia.

I. THOMAS, Registrar of Cereal Varieties in Australia.

During 1946 two new wheat varieties Insignia and Pinnacle were registered. Both were sponsored by the Victorian Department of Agriculture and the particulars of the new varieties as supplied to the Registrar are as follows: —

Insignia.—An early maturing variety selected at the Mallee Research Station, Walpeup during the period 1933/37 from a cross between Ghurka and Ranee. The straw is yellow and strong and although relatively short it is a taller growing variety than Ghurka. It stands better than comparable early varieties. Insignia heads earlier than Ghurka or Ranee and is approximately similar in this respect to Regalia. The ear is of medium length, slightly tapering and although free threshing, does not shed. The outer glumes are red-brown and lightly awned whilst the grain is of medium size, yellow and equal to the better parent, Ranee in respect to flour strength.

Insignia is resistant to flag smut and less susceptible to rust than is Ranee. As the (Ghurka x Ranee) cross-bred M.6173 T14-2-1-1 Insignia was tested for five years at the Walpeup Research Station and other centres in the Mallee and gave consistently higher yields than Ranee 44, Regalia, Bencubbin, Pindar, Baldmin, Quadrat and Ghurka. It is therefore recommended by the Victorian Department of Agriculture for cultivation in the Mallee districts of that State.

Pinnacle.—Selected at the State Research Farm Werribee in 1934. Pinnacle is a midseason maturing variety slightly later than Pindar. The straw is yellow, short and strong but slightly taller than Ghurka. The ear is large and compact, free threshing but non-shedding. The outer glumes are red-brown and awned with large, yellow, shotty grain. The flour strength is superior to Pindar and Ranee and it is resistant to flag smut. As the Pindar selection W.603V it was tested for four years in replicated trials at Longerenong College, Salisbury, Kaniva and Charlton and gave higher yields than Quadrat and Ghurka. The Victorian Department of Agriculture recommends it for cultivation in the Wimmera District.

Produce and Market First Quality Eggs.

E. LOVEGROVE and S. FROOME.

THE yearly consumption of eggs per capita in Australia is so absurdly small that the poultry industry is forced to export a much larger percentage of its production than would be necessary if the public fully realised and justly estimated the value of eggs in the national diet. The Bureau of Agricultural Economics estimate that it cannot be expected that the consumption of eggs in Australia for the year ending June 30th 1947, will exceed 65 million dozen. With a population of approximately 7,411,000, it appears that each individual may consume 105 eggs during the year. The estimated consumption of eggs per head in the United States of America, for the same period, is 360 and during the war years it reached 390.

If each person in Australia would eat, on the average, only 3½ eggs a week the entire production would be consumed within the country and the poultry industry could expand to the limit of the visible overseas markets.

Under present conditions, however, the poultry industry can only maintain its position, or possibly expand, by the results of its overseas sales. The success of any marketing authority is bound up in the quality of the product it has to sell and it is axiomatic that the better the quality the easier the sale and the greater the demand for that particular product.

England is the principal overseas buyer of Australian eggs, and she requires. and is willing to purchase at a reasonable price, many millions of dozens to feed her people, but she expects to receive a first-class article.

In order to ensure that wastage, due to rots, in eggs in shell shipped to the United Kingdom be reduced to a minimum this season the Department of Commerce has decided that washed eggs cannot be accepted for export. This decision

was reached after scientific research had definitely established that the terrific wastage was due to the entry of bacteria into the egg through wet cleaning. It may be thought that the banning of washed eggs for export would cause the accumulation of stocks so large that the limited disposal avenue of the local market would be glutted with a consequent collapse of prices. This contingency might arise if two limiting factors were not used to their utmost extent.

Australia is committed to export a large number of cases of eggs in shell and pulp to Britain this season and to fulfill her pledge every egg of export quality should be packed. To assist in carrying out this project the Department of Commerce has agreed to accept slightly soiled eggs provided they otherwise comply with the required standard. Consequently, eggs will be accepted for export which would have been rejected when the Department of Commerce insisted on a scrupulously clean shell. The second factor is perhaps, the more important; it is the adjustments that the poultry farmer will be required to make to produce a high percentage of clean first quality eggs which the future of his industry demands.

FACTORS INFLUENCING QUALITY BEFORE THE EGG IS LAID.

The quality of an egg cannot be improved after the egg is laid, therefore, any factor which may improve, or any condition which may have an adverse effect on the quality should receive special consideration. The original quality of the egg is mainly bound up in poultry breeding and attention to genetic factors which control the production of high quality eggs.

Shell Texture: The shell can be considered as a container, holding and preserving the quality of the contents; should the container be imperfect it is reasonable to suppose that the contents would quickly deteriorate. Therefore, the first consideration should be given to producing eggs with shells of good shape and texture. The detailed records of the Muresk Egg Laying Trials have demonstrated that each hen lays eggs which are characteristically distinct to that particular hen for colour, shape, and shell texture. Should a hen continually lay eggs that are misshapen, ridged, excessively porous, chalky or thin shelled she should not be included in the breeding flock. These faults are, in the main, hereditary and can be remedied by selective breeding. Considerable loss occurs during all the stages of marketing due to weak shells, and owing to the deterioration of roads and railway rolling stock, during the war period, greater shell strength is needed to withstand the hazards of transportation. Chemical analysis disclose that the average shell contains 37.8 per cent. calcium and .2 per cent. phosphorus, and since eggs carry a relatively high percentage of calcium it is obvious that a hen will require more calcium as the rate of production increases. On the contrary, a deficiency of calcium in the diet will not materially affect the percentage composition of the shell but as the deficiency becomes more pronounced the shell tends to become thinner with ultimate cessation of egg production. For maximum egg production, the variation in calcium requirements of hens, under varying rates of production in the flock, are met by allowing the flock free access to oyster shell or high grade shell grit in addition to the calcium which is supplied in the diet. The common calcium supplements used are oyster flour and bonemeal; the former being approximately 38 per cent. calcium with only traces of other minerals. Oyster shells should not be used as a grit because of their high solubility. Steamed or sterilized bone meal is ordinarily considered as a phosphorus supplement, but it supplies calcium in the ratio of about 2 parts to one part of phosphorus. Therefore, when bone meal is added to a diet it supplies important amounts of calcium, but it is a more expensive product than oyster flour and for that reason is not an economical calcium supplement.

The concept of bone formation (Tyler, 1940), during the laying period particularly, is that the bone is formed of a skeletal lattice work of tri-calcium phosphate which is constant, but that the calcium within the cells formed by this lattice work is in the form of calcium carbonate. This storage is the means of providing the fluctuating amounts of calcium necessary for the formation of shells during active egg production, although there is a relationship between the two forms of calcium which prevents complete exhaustion of either supply.

In practice, it has been found that the average amount of oyster shell consumed per bird per year is approximately 3¼ lbs. Under usual conditions a mixture of 1/3 oyster shell and 2/3 good grade sea shell serves most purposes.

Infertile Eggs:

For market purposes infertile eggs should be produced; male birds should not be kept with the laying flock. One of the causes of egg spoilage is the development of embryos in eggs during the summer months when high temperatures prevail. When fertile eggs are subjected to temperatures within the incubation range, which begins at as low as 68°F. the germ will begin to develop. This development will take place slowly or more rapidly, depending on how favourable the temperature conditions may be, and may result in a relatively short time in development of the embryo to the point at which blood veins

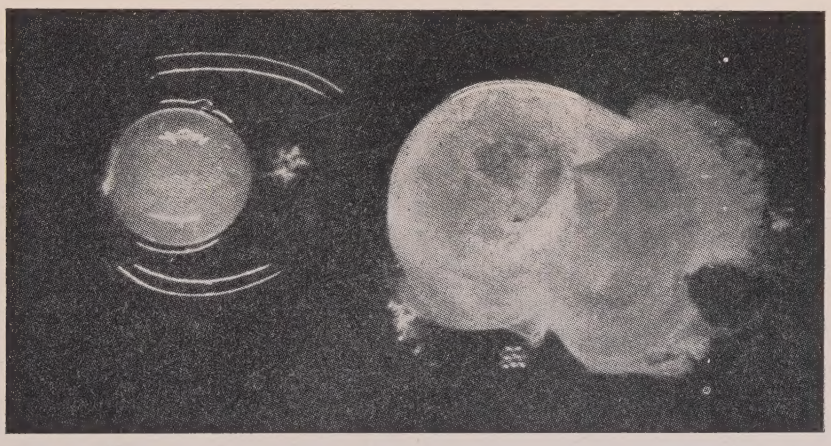


Fig. 1.—Infertile egg at left, fertile egg at right after being kept four days at 100° F. (Photo. University of Missouri Res. Bull. 362.)

are formed and the egg is no longer edible. Recent research, by the University of Missouri, in stabilizing embryonic development shows that the immersion of fertile eggs in still water at temperatures between 136° to 140°F. for 10 to 15 minutes stopped embryonic development and the edible quality of the eggs was retained. Fig. 1 shows the difference between an infertile and a fertile egg held for 4 days at 100°F. and it is evident that under summer conditions only infertile eggs should be produced if good quality eggs are to be marketed.

The Effect of Breeding on Egg Quality:

Some important characteristics governing the commercial quality of eggs are hereditary. Some of these characteristics are egg weight, proportions of thick and thin albumen, and deterioration of egg white. Therefore, by selective breeding for each of these particular characteristics an improvement can be

made in egg quality, but it must be understood the points mentioned are only some of those which should be considered in a definite genetic breeding plan. Since the inception of the Muresk Egg Laying Trials, in 1927, breeders in Western Australia have realised the value of breeding for weight of egg and it is noticeable that the time required by pullets to lay eggs of 2 ozs. in weight has been reduced. It is generally conceded throughout the industry that it is necessary to breed from second season hens if strong and livable chicks are to be produced, and the practice of breeding from pullets is not recommended. When selecting a hen for the breeding pen it is of prime importance to have a record of her laying in her pullet year. Records of experimental work carried out at Muresk College show that many hens lay 2 oz. eggs in their second laying season, who in their pullet year produced a majority of underweight eggs. It is thus misleading to select a hen as a breeder on the weight of egg laid in the second laying period. Fig. 2 shows two typical examples of this type of layer.

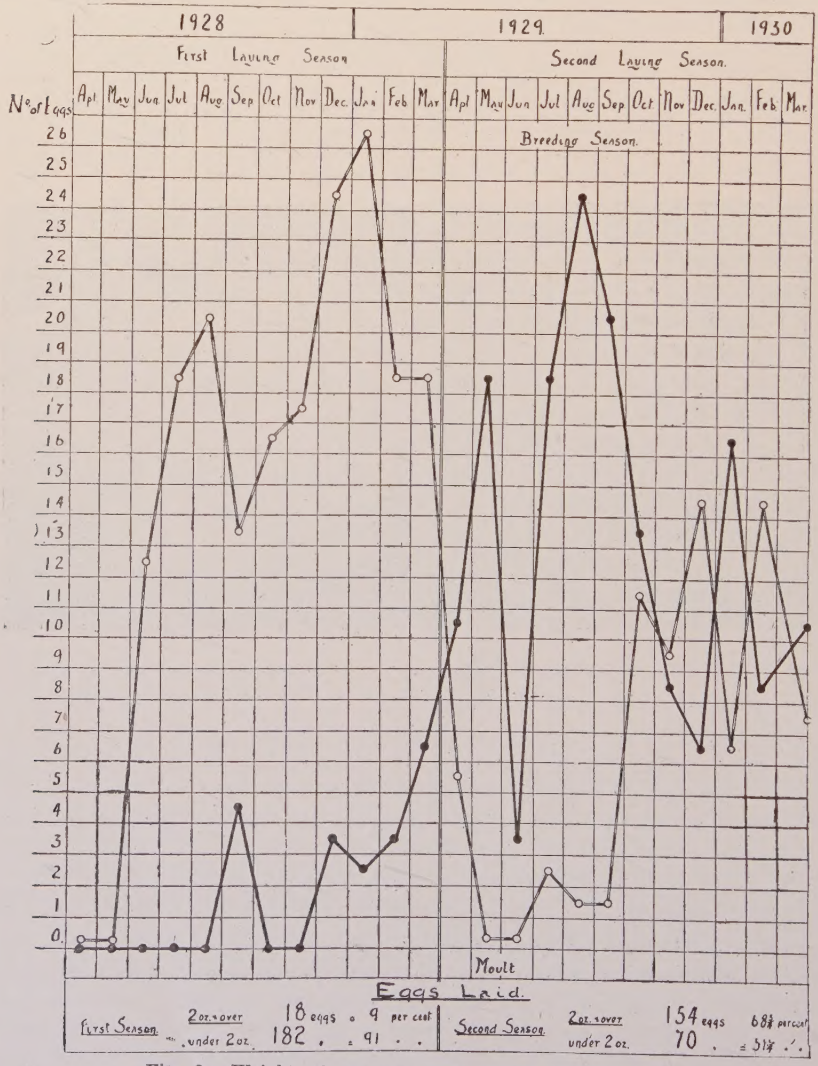

1928
1929
1930
First Laying Season
Second Laying Season
No. of Eggs
Apl May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
Apl May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
Breeding Season.
Moult
Eggs Laid.
First Season 2 oz. & over 18 eggs = 9 per cent
under 2 oz. 182 " = 91 " "
Second Season 2 oz. & over 154 eggs 68⅔ per cent
under 2 oz. 70 " = 31⅓ " "

Fig. 2.—Weight of egg first and second seasons' laying.

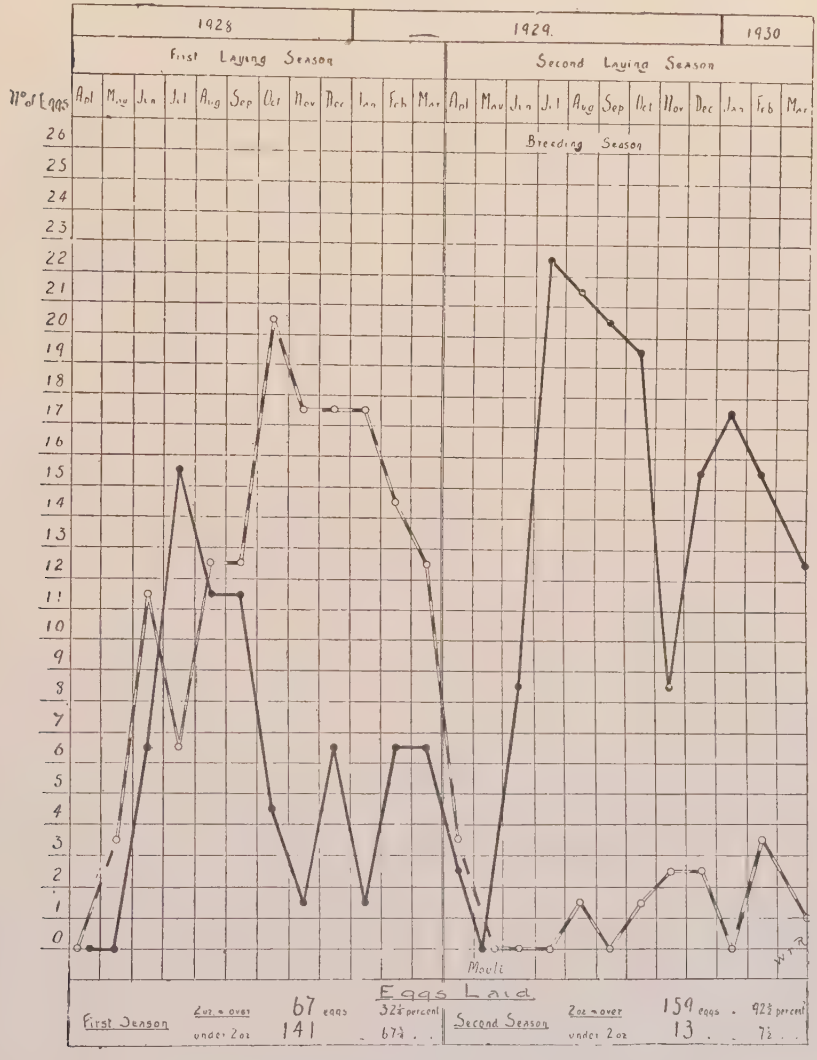

1928
1929.
1930
First Laying Season
Second Laying Season
No. of Eggs
Apl May Jun Jl Aug Sep Oct Nov Dec Jan Feb Mar
Breeding Season
Moult
Eggs Laid
First Season
2 oz. & over 67 eggs 32¾ per cent
under 2 oz. 141 " 67¼ " "
Second Season
2 oz. & over 159 eggs 92¾ per cent
under 2 oz. 13 " 7½ " "

Fig. 2.—Weight of egg first and second seasons' laying.

A circular published by the United States Department of Agriculture states that "the percentage of thick albumen is an individual and hereditary characteristic. Data obtained indicates that by proper selection a strain of hens can be developed that will lay eggs having a high percentage of thick white.

The degrading of many eggs, when candled on the market floor to second quality is due to their high content of thin albumen. This type of egg which is known as a "watery white" when candled shows a thin white, a fast moving yolk, and generally an enlarged air cell due to the rapid evaporation of the thin albumen. To breed only from those birds who lay eggs containing a high proportion of thick albumen would require the single testing of each bird for

this factor, but this may not be possible for the commercial farmer with limited time at his disposal. However, he can markedly reduce the incidence of thin whites by candling every egg before it is placed in the incubator and reject any which show that peculiarity.

Fig. 3.—Eggs after cooking showing on left thick albumen and on right thin albumen.
(Photo. U.S.D.A. Circular 583.)

The results of other research work, undertaken by the same authority, indicates that the rate of deterioration of thick white appears to be hereditary. Although there was no significant difference when fresh, the eggs produced by different lines of White Leghorns differed materially after they were held. Fresh eggs from two lines had exactly the same percentage of thick white, but after these eggs had been held at approximately 78°F. for 21 days under the same environmental conditions, the percentage of thick white for those in one line was 32 per cent. and for those in the other line 13 per cent. This work indicated that the rate of deterioration of thick white depends on hereditary factors as well as on conditions under which the eggs are kept.

Research work undertaken by the Ministry of Agriculture and Fisheries, England, and by the University of Illinois, U.S.A., indicate that meat spots and blood spots are pathological conditions associated with the individual hen rather than the feeding of high proportions of protein in the diet. The possibility of aggravating these conditions by the inclusion of high proportions of animal protein in the diet is not, however, ruled out. Certain families and individuals, as well as certain strains, are much more disposed to the production of blood spots than others. Blood spots can be greatly increased or decreased by selection within a blood spot strain.

The Effect of Feeding on Egg Quality:

Widely speaking, the feeding practices in operation on commercial poultry farms in Western Australia are such that good quality eggs should be produced under normal conditions, but a few points may be of interest.

The public prefer a richly coloured yolk; therefore, from a marketing point of view the colour of the yolk is extremely important to the commercial egg producer, for he must satisfy this preference if he wishes to create a demand for his product. Yolk colour is not a breed characteristic, but is largely determined by the conditions of feeding.

Oats, wheat, milk, meatmeal and their by-products give rise to pale yellow coloured yolks, but maize, green food, generally, and lucerne meal produce richly coloured yolks. Feeding cabbage or clover in abundance gives an orange-red colour to yolks. Linseed meal is said to give rise to yolks of a greenish colour, and the abundant feeding of rape will produce yolks of an olive tint.

If there is more than 5 per cent. of cotton seed meal in the diet, the yolks tend to become mottled if the eggs are stored for some months; also the whites may acquire a pink tinge.

The use of the last three foods in a laying ration should be restricted.

Apart from the influences of breeding, as noted above, nutrition is a factor in the production of blood spots in eggs. When birds are allowed fresh green feed daily there is a reduction of the incidence of blood and meat spots.

As regards size or weight of egg, although genetic breeding must be practised to maintain this factor, it is also necessary that the diet should contain 15 to 16 per cent. of protein and about 20 per cent. of this protein should be derived from animal sources. In general, if the diet contains some dried skim milk or dried buttermilk the eggs tend to be slightly larger than if these feedstuffs are not used.

As the public are now vitamin conscious, it is worthy of note that the vitamin content of eggs may be affected by diet. The content of vitamins, A, B1, G and D in the egg can be increased by feeding diets that contain relatively large quantities of these vitamins. The following are the better sources of:—

Vitamin A.—Cod-liver oil, certain shark oils, and the carotenoids in green plants are converted into Vitamin A when fed to poultry.

Vitamin B1.—Dried yeast, liver, bran and pollard.

Vitamin G.—Dried whey, dried buttermilk, dried skim milk, fish meal, and in green plants, particularly lucerne.

Vitamin D.—Cod-liver oil and it is developed in the body of the bird by exposure to sunlight.

Conditions influencing quality after the egg is laid:

Since no methods are known of improving the initial quality of eggs after they are laid, or of restoring quality already lost, it is of the utmost importance that the original quality should be preserved as far as possible. Research work by Dr. E. M. Funk of the University of Missouri, on the thermo-stabilization of quality in shell eggs, has demonstrated that the normal breakdown of thick albumen can be greatly retarded, and the vitelline membrane surrounding the yolk can be made to retain its strength for a longer period. The treatment consists of applying heat at a relatively low temperature (about 140°F.) for a period of approximately 10 minutes. At some future date it may be possible to erect plants at the markets to stabilize the quality in shell eggs by this treatment but it will still be the responsibility of the poultry farmer to deliver the eggs to the treatment plants in the highest quality condition. Quality declines with the age of the egg, the rate of decline being dependent upon environment conditions such as temperature and humidity, whether or not the egg becomes contaminated, methods of handling, and other factors. It would assist to retain quality if all persons handling eggs would remember that eggs are a food and although the edible portion is encased in a shell, they should be handled with care and with clean hands.

From an economic point of view the second quality egg is an actual and substantial loss to the poultry farmer. The following table shows the loss to producers on second quality eggs received under control in W.A. in the last 2 years:—

	30th June, 1945.	30th June, 1946.
Number of 2nd quality eggs (Hen)	489,743 doz.	508,359 doz.
Percentage of total receivals	10·29%	9·82%
Number of 2nd quality eggs (Medium)	137,993 doz.	86,521 doz.
Percentage of total receivals	2·90%	1·67%
Total number of 2nd quality eggs	627,736 doz.	594,880 doz.
Percentage of total receivals	13·19%	11·49%
Average difference in price between 1st and 2nd quality	4d. per doz.	4d. per doz.
Actual loss to producers	£10,462	£9,914

This shows a loss to the producers of £20,376 in two years, most of which could have been saved by correct methods of production and marketing.

Fig. 4.—Wire netting of perches to prevent fowls gaining access to night droppings. Note wire netting extends down front as well as immediately beneath.
(Photo. Govt. Printer, Property M. Stocker.)

Environmental conditions in the laying shed.

No apology is offered for reiterating and stressing the sanitary conditions which should be present in all laying sheds. The salient points are:—

(a) Provide ample floor space in the shed, 3 to 4 square feet for each laying bird.

(b) Provide a concrete floor and keep it covered with clean litter.

(c) Fasten wire netting to the underside of the perches to prevent birds from having access to the droppings. (Fig. 4.)

(d) Clean out the droppings at regular intervals and, when the litter becomes dirty, clean the shed thoroughly and provide new, clean litter.

(e) Keep the nests filled with clean nesting material. White shavings, white sawdust, clean dry sand, and shellgrit have given most satisfaction as nesting material.

(f) In wet weather, when the birds will have muddy feet, keep the laying flock confined to the shed until midday. The majority of the eggs will have been laid by that time, but the eggs should be gathered at least twice in that period. The type of laying shed recommended by the Department of Agriculture is designed for this purpose.

(g) Cover the nests at night to prevent the hens from roosting in the nests.

(h) Remove all broody hens from the laying shed immediately they become broody.

Gathering the eggs:

Gather eggs at least three times daily; twice in the morning and once in the afternon.

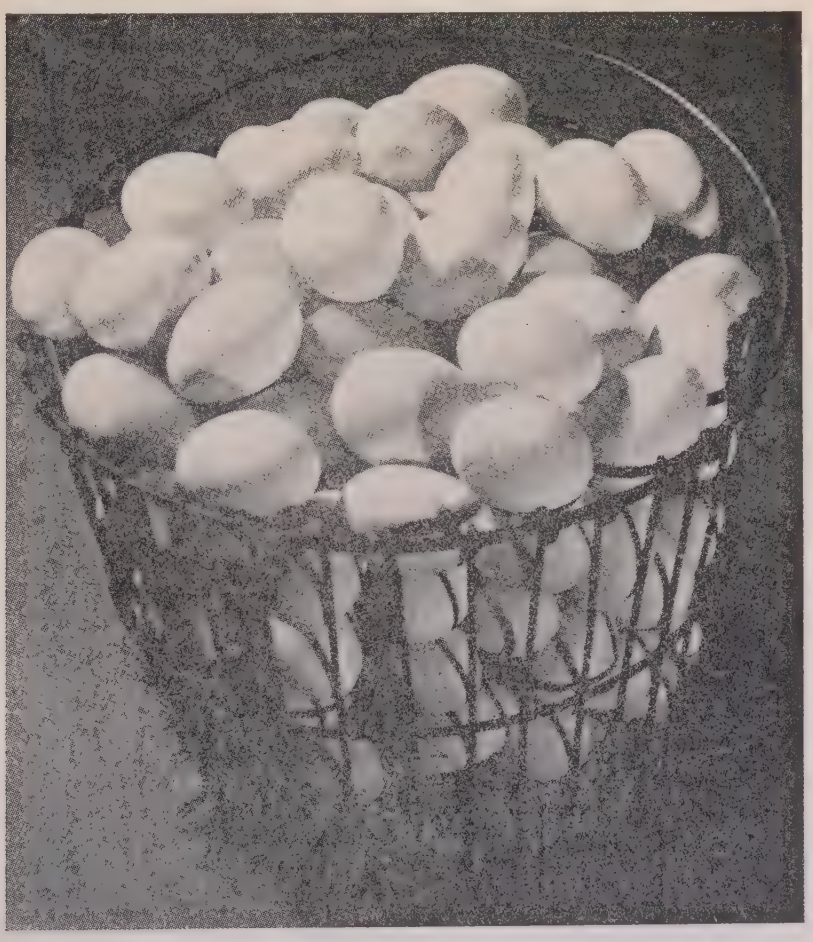


Fig. 5.—Wire egg baskets are invaluable for gathering eggs on the farm.
(Photo. University of North Carolina Ext. Circ. 275.)

Procure some wire baskets, as shown in Fig. 5 and gather the eggs in them. Wire baskets are superior to buckets for they allow the eggs to cool down quickly. In order to retain the interior quality and flavour in the egg the animal heat must be removed as quickly as possible.

Handling quality eggs on the farm:

From the time the eggs are gathered until they reach the market is a period when much damage can be done to quality if a correct routine is not followed.

Fig. 6.—Wire egg trays for fitting into cooler. These are invaluable for holding eggs prior to packing for market.
(Photo. University of North Carolina Ext. Circ. 275.)

Cooling:

Although a wire basket may have been used to gather the eggs and allow of a certain amount of cooling, it is preferable to spread them on wire bottom trays to ensure rapid cooling. Fig. 6 shows a type of tray that is suitable and several of these could be fitted into a cooler known in Western Australia as a "Coolgardie Cooler." Eggs should never be packed in cases the same day that they are laid unless they have been thoroughly cooled. It is generally recognised that the quality of an egg is best when laid but its temperature is that of the hen, 104° to 107°F., and if it remains too long at near that temperature the quality of the white begins to deteriorate. The optimum range of temperature for holding eggs on the farm is 40° to 55°F., but they should not be cooled to a temperature lower than 40°F. because if they are later subjected to a comparatively high

temperature in transportation, condensed moisture may form on the shells. Research work has demonstrated that, if eggs are held on the farm at the suggested temperature, the differences in albumen quality between eggs one day old and five days old is rather small and not of much practical importance.

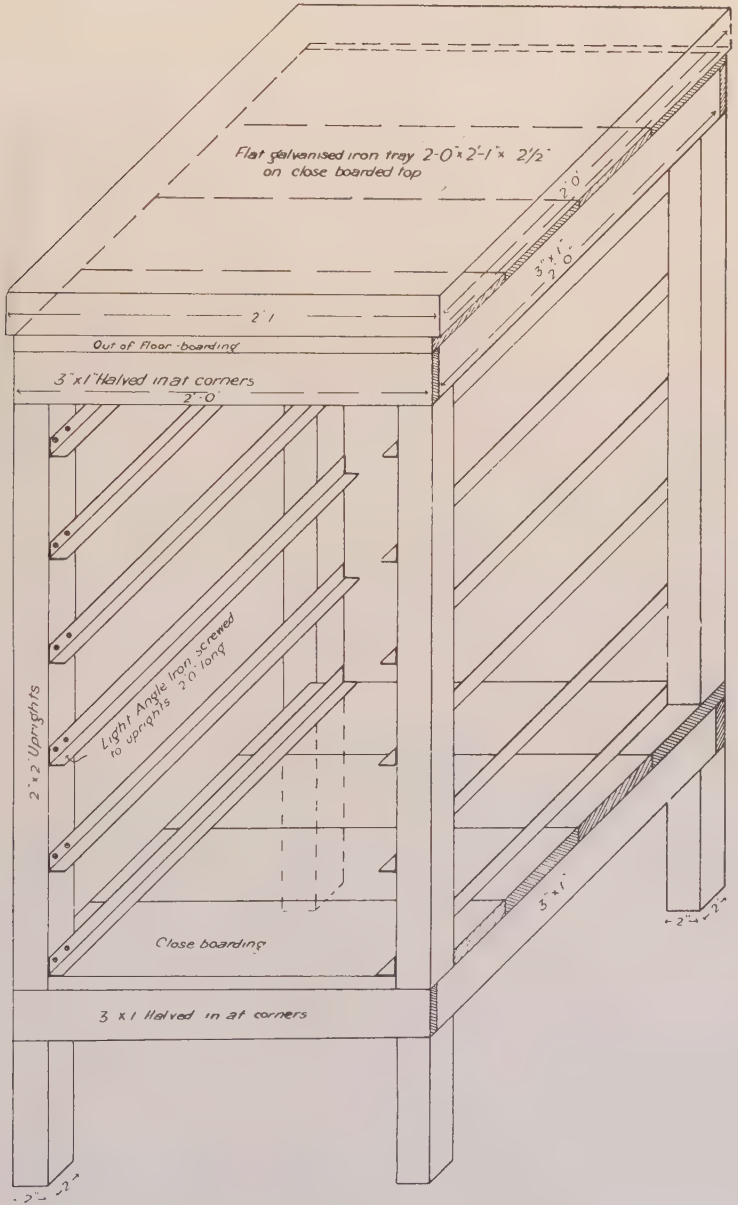


Fig. 7. —ECC COOLER— suggested design
(NOT TO SCALE)

An inexpensive egg cooling rack can be constructed on the lines of the "Coolgardie Cooler," which has proved successful in South Australia. Fig. 7 shows a suggested design which can be easily constructed on the farm. Owing to the recent advance in electric cooling, it is likely that refrigerators designed to meet the special needs of the poultry farmer may soon become available, but unprotected eggs lose moisture rapidly in an ordinary family refrigerator.

Moisture:

To retain good quality in the eggs moisture is just as necessary as keeping them cool, especially in a warm, dry climate. An atmosphere which is cool and has a fairly high relative humidity protects the contents of the egg from evaporation and consequent shrinkage, and prevents the rapid enlargement of the air cell. However, too high humidity and stagnant air are likely to result in the development of mould on the eggs, quickly making them inedible. When eggs are candled the depth of the air cell is considered one of the indicators of age, but this is only a true sign if the conditions under which they have been held are known. If eggs are held, during warm weather, in a room where a current of dry warm air passes over them the evaporation of the contents will be so great that the air cell depth would indicate an age of at least 14 days when in reality it may only be of two days. The air cell depth coupled with the fact that the white would have commenced to lose its quality would cause these eggs to be degraded to second quality.

Summing up the internal changes that may take place before the eggs reach the market: The air space increases in size because of loss of moisture by evaporation; the weight decreases; the white tends to become thin; and the yolk membrane weakens. General conditions which are necessary to retard these changes suggest that eggs should be cooled quickly and stored in a cool, fairly moist, well ventilated place, where the temperature does not vary greatly, and where there are no objectionable odours such as kerosene, onions, etc.

Packing, handling and transport:

To assist in preserving egg quality it is advisable, during hot weather, to precool the cases and fillers before eggs are placed in them. When cases and fillers have been stored in a dry, warm storeroom the moisture they originally contained has evaporated and they are in a condition to absorb moisture from the eggs as soon as they are packed. Two or three days before the cases are to be used they should be placed in a cool, moist room, preferably above a concrete floor that has been sprinkled with water or on the slatted top of a large shallow sand box; the sand being kept wet by pouring a bucket of cold water over it each day.

It is now universally known that eggs should be packed with the large ends up to preserve the position of the air cell but it is not realised the damage that can be done to the air cell by careless handling in the short journey from the nest to the packing room and on to the market.

When eggs are subjected to jars or shocks in handling and transport, there is a tendency for the air cell to become "tremulous," that is, the shell membranes become separated over a larger area than that occupied by the air cell itself, and this permits a tremulous movement of the air cell as the position of the egg is shifted before the light. In some instances, the air cell may be "free" in the egg, permitting it to assume the uppermost position in the shell no matter how the egg is turned. This is due to the rupture of the inner shell membrane leaving the air free to move to a space over the contents of the egg.

However ideal the holding conditions on the farm it is still necessary to market eggs frequently; for although the quality may not deteriorate to any extent, it cannot improve. Therefore, eggs should be sent to market at least twice a week and more frequent deliveries are desirable.

Where there are no special facilities for transporting eggs to market, careful hauling will repay the producer. Precautions against unnecessary jolting should be taken and eggs should be covered to protect them from the warm sun. To maintain the original quality as long as possible in so perishable a product requires great precaution in caring for eggs on the farm and through all the steps to bring them to the consumer, but with correct procedure a first quality egg can be delivered to the consumer.

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The Soybean.

ITS POSSIBILITIES IN W.A.

By H. G. Elliott, Agrostologist.

THE world's production of soybean is probably in excess of 7,000,000 tons annually—Manchuria, the largest producer, is followed by China, Japan and the United States of America; very little at present is known with reference to the production in Russia. In Australia the acreage grown is as yet only small and up to the present time has been mainly experimental.

ECONOMIC POSITION.

The Manchurian production up to the time of the last war was still the most important in the world and controlled the export market for soybeans. China, United States, Chosen, Japan and Netherlands East Indies are producers of this bean but mainly for their own use. Bulgaria, Czechoslovakia and Russia are also producers but in comparatively small quantities.

Of the total Manchurian production prewar—⅓rd was exported to each of Europe and Japan and ⅓rd was required for own use.

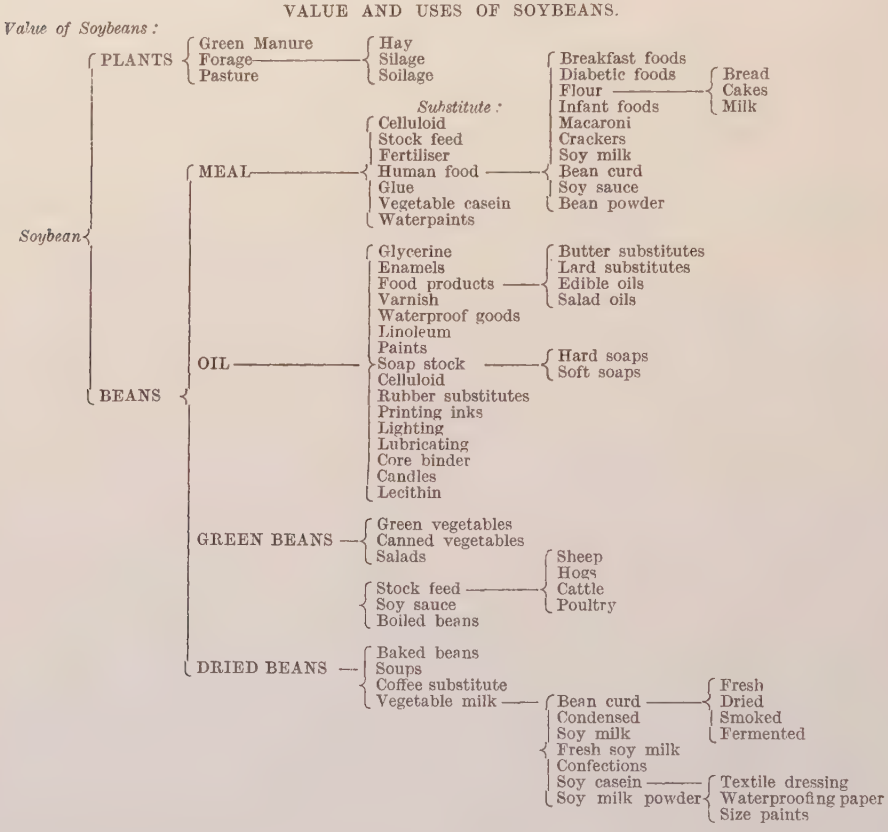
Practically all of the European States were importers of this oil and the U.S.A. produces only enough for their own requirements. In 1936 America produced 30,000,000 bushels of which 20,000,000 bushels were used for crushing.

SOYBEAN OIL.

The yellow seeded varieties of this bean are the most suitable for oil production, whereas the Black and Brown seed types are suitable for silage, hay and forage but undesirable for crushing for oil. For the extraction of oil there are three methods used, i.e.:—

(1) The expeller method—commonly used in U.S.A.
(2) Hydraulic Press method—sometimes used in U.S.A.
(3) Solvent-Extraction method—used in Europe.

The oil content of the beans is between 18-19 per cent. on a natural moisture basis, but there are varieties known which contain up to 23 per cent. of oil. In America the average yield by the crushing methods is 14 per cent. or 8.4 lbs. of oil per bushel, of 60 lbs. of seed. The yield of cake is 80 per cent. or 48 lbs. per bushel; the balance of 6 per cent. or 3.6 lbs. represents waste. One lb. of oil is valued at from 2-5 times the value of 1 lb. of cake, consequently, the best price is obtained from 1 bushel of beans when the most efficient method of extraction of oil is used. Of the methods of extraction used the solvent method leaves 5 per cent. of the oil remaining in the cake and the expeller and press methods leave 21 per cent. to 22 per cent. of the oil in the cake.



USES OF OIL.

During 1931-34 the most important outlet for the oil in America was the paint and drying oil industry. During 1936, 81 per cent. of the factory consumption of the oil was in food products and only 9 per cent. in the drying oil industry. In spite of this (81 per cent. Soybean oil used in food products), Cottonseed oil still dominates the edible oil field as 52 per cent. of the primary fats and oil in used food products was Cottonseed and only 6 per cent. was Soybean.

With reference to drying oils in America, 53 per cent. was Linseed oil and 3 per cent. was Soybean oil. Soybean oil is a semi-drying oil with an Iodine No. 134 and Linseed oil is a drying oil with an Iodine No. 188.

The Soybean oil must be used in combination with some other oil, paints made with Soybean oil do not yellow with age and consequently it is used in pale coloured enamels and paints for interior use. Other than this, however, its use is limited to 10-50 per cent. of the oil used.

In food products Soybean oil has a tendency to acquire an unpleasant flavour on ageing and generally is used only in low grade products which have a quick turnover. Thus at best it is only a substitute oil with a limited market.

ORIGIN.

For many thousand years the soybean has been grown in Manchuria where it is a staple crop and provides the bulk of the food of the native population. However, the export value of the bean has been, and still is, the main source of revenue of the country. China is also a large grower of the bean and these two countries in pre-war days produced about 80 per cent. of the soybeans grown throughout the world. In recent years Japan and Korea have increased the acreage sown to this crop.

Soybean, showing flowering branch, flower, leaves and pods.

The United States of America, prior to the war, grew over 500,000 tons of soybeans. In the United Kingdom, prior to the war, certain selected varieties were produced which were suitable for growing in their climatic conditions and an increase in acreage grown is still occurring.

USES IN WESTERN AUSTRALIA.

As has been shown this bean has a wide range of uses but at the present time it is doubtful if it could compete as a fodder with other summer grown ones in this State. The selection and breeding of varieties suitable to our particular climatic conditions may eventually place this bean in the position whereby it can be grown profitably.

The dried bean which is rich in protein and oil, is suitable for canning, also for the preparation of diabetic and other human foods but finds its greatest use in industry where it is a valuable source of oil for the manufacture of foods, paint, and many other purposes while the residue is utilised for human and stock foods and for the manufacture of plastics, glues and paints.

NAME AND ORIGIN.

This plant has been given numerous names, several of which appear to be in common use; thus it is known as *Glycine max, Glycine hispida, Soja max* and *Soja hispida*. W. Reide (Germany) names it *Soja hispida* and points to *Soja ussuriensis,* a wild form growing naturally in Manchuria, as the parent form. He distinguishes two groups of species of the genus *Soja.*

(1) *The Tropical Group.—Soja javanica, S. Toinentosa* and *S. pentaphylla* found growing in Java, the Phillipine Islands, India, etc.

(2) *The Temperate Group.—Soja ussuriensis,* a wild specie; *Soja gracilis,* a semi-cultivated specie; *Soja hispida,* a cultivated specie.

Soja ussuriensis grows wild in north-east Manchuria; the hill country between Ussuri and Sungari is the home and principal area of distribution of this parent species, which is found in many parts of Manchuria, Japan, China and Korea.

DESCRIPTION.

The soybean is an erect, bushy, leafy annual which branches profusely from nodes at the base of the stem. When it is crowded or grown too closely in the rows very little branching occurs. The leaves are trifoliate, occasionally having four or five leaflets. The first leaves above the cotyledons are simple and opposite. Compound leaves arise at the nodes and alternate. The leaves of varieties which have yellow cotyledons turn yellow before falling, the leaves of other types fall off without turning yellow.

The flowers are borne in racemes or peduncles in the nodes. The flowers appear first at the base of the main stem and then progressively towards the tip. The period of flowering does not usually last longer than 3 weeks. The pods contain 1-4 seeds and this variation occurs within individual varieties. The plants are normally self fertile. Pollination occurs a little before, or as soon as the flowers open. A small amount of natural crossing does occur, but where this has been investigated it has been found to be less than 1 per cent. Natural crossing is believed to be due to Thrips tobacci and may be due in some instances to honey bees.

CLIMATE.

The soybean thrives best in a monsoonal climate with great summer warmth, heavy summer rainfall and a high degree of humidity. The beans are susceptible to frost and must be grown in regions which are free from frost during the growing season. If drying winds occur during the flowering period, poor seed setting and a high proportion of bladder pods occur.

Generally speaking climatic conditions suitable for the growing of maize for seed are required for these beans.

In this State it is considered that areas sheltered from hot, dry winds and where irrigation can be practised if the land is not retentive of summer moisture, should give good results. Many of our coastal swamps would probably be suitable. Experiments with many varieties have been tried and still are being tried in various localities in the South-West, and also at the Ord River and Carnarvon.

SOILS.

Soybeans can be grown on many types of soil, such as sandy, loamy and clayey types. They prefer alluvial soils and loams. Well drained soils are an advantage, although the plant is able to withstand a considerable amount of soil moisture for short periods. These beans succeed better on acid soils than is the case with lucerne.

CULTIVATION.

The land should be plowed at least 4-5 inches deep with a mouldboard plow in the early spring months, and left in fallow for 2-3 weeks, when the land should be then worked down by means of cultivators and harrows. The final preparation consists of obtaining a fine surface layer with a well compacted subsoil.

Soybeans drilled in rows two feet apart to permit tillage.
(Photo. Illinois Agricultural Experiment Station, Bull. 453.)

FERTILISER.

Two cwts. of superphosphate per acre is considered suitable for this State. The fertiliser should be thoroughly incorporated in the soil before the seed is sown as the seed is readily damaged by contact with fertiliser; apart from the damage to the seed there is a possibility of the fertiliser injuring the nitrogen fixing bacteria, which is applied to the seed prior to planting.

INOCULATION.

Soybeans are legumes and as such require the presence of nitrogen fixing bacteria on their roots before they reach maximum development. A strain of bacteria (Rhizobium) suitable for this bean is available at the Department of Agriculture. The inoculum is placed on the seed, prior to planting. Full particulars as to how to inoculate the seed are supplied with the bacteria when obtained.

SOWING.

The seed is sown as soon as the land is sufficiently prepared and when the danger of frost is past. The seeds are sown at a depth of 1 inch: depths greater than 2 inches are harmful. A loosening of the soil crust by light harrowing before the plants come through and after the germinating rains, is an advantage. The beans should be planted in rows 2½ to 3 feet apart with 4-6 inches between plants. In this case, five to twelve pounds of seed are required per acre, according to the size of the seed and the variety sown. Sowing may be done with a maize drill with a special plate or by means of a wheat drill by blocking up all but a few of the tubes.

Differences between varieties in growth habit.
No. 1 is an early maturing type with a low yield of both seed and hay.
No. 2 is a typical bunch variety with a low hay but a fairly high seed yield.
No. 3 is a dual purpose type with a seed and hay yield.
(Union of South Africa, Bull. No. 240.)

INTERCULTIVATION.

Two or three cultivations are usually given between the rows during the growing season. This is done to control weeds and to allow moisture to soak in if rains occur.

HARVESTING.

The beans may be grown for silage hay or seed.

(1) *Silage.*—Cut when seed is well developed but before any of the leaves fall away. Silage produced from soybeans is too rich in protein and fats and is not relished by stock. Soybeans make more palatable silage when mixed with twice as much maize. It gives a flavour and odour to the milk.

(2) *Hay.*—Soybeans are cut for hay when the pods are well formed. If left later the stems harden, the leaves fall and the percentage of protein decreases. Cutting is done in the morning after the dew has disappeared. When it is well wilted it is raked into windrows and haycocks. The development of the pod is found to be the most reliable guide of the time of harvesting.

(3) *Seed.*—Non-shattering varieties may be left much longer than shattering varieties. They are usually harvested when most of the leaves have fallen and when the pods are about one quarter filled. The development of the brown colour in the pods serves as a good index of the time of harvesting.

Harvesting should be done on a damp cloudy day or when the dew is on the plants to avoid shattering. The seeds heat readily and should be thoroughly dried before stacking.

VARIETIES.

A large number of varieties of soybeans are known which vary in the length of their period of maturity, and experimentation is necessary to define the varieties most suitable to various districts. However, the Council for Scientific and Industrial Research have obtained best results with Charlee, Haberlandt, Creole and Georgian varieties in Queensland, whilst Manchu Yellow and Haberlandt, have been grown with some success in Western Australia and yields as high as 35 bushels per acre have been obtained experimentally.

SUMMARY OF SOYBEAN TRIALS IN W.A.

The Department of Agriculture in this State has for many years introduced numerous varieties of soybeans for trial at various centres over a wide range of soil and climatic conditions, from as far North as the Ord River in the Kimberleys to Albany on the South coast, and the results to date have not been completely successful.

The early trials did not meet with much success because of three main factors—

1. Inability to obtain good inoculation on plants as a suitable strain of bacteria for inoculation of seed was not available.

2. Suitable strains and varieties of soybeans were not available as those tried were too long in maturing.

3. Low germination of seed imported for trial.

In recent years better results have been obtained as—

1. Suitable bacteria for inoculation is available.

2. A larger range of earlier maturing varieties has been obtained for trial in the South-West. Time of maturity is not a major factor in the North.

Of the varieties grown in the South-West, Manchu Yellow, Haberlandt, Arysoy, Easy Cook, Harrow Mammoth Brown, Kenway and Q1463 have all given reasonable results and yield up to 30 bushels per acre of seed have been obtained from them. Seasonal conditions at the time of flowering appear to play an important part on yield as hot dry weather with high wind at flowering time appears to cause the non-setting of the seed but the production of bladder pods.

At the present time a large range of soybean varieties is under trial at various centres.

SOYBEAN VARIETIES—AMERICAN.

Variety	Average No. of days to mature.	Yield bus./acre.	Seed Colour.
Ito San	89	29.5	Y
Ohio 9100	89		
S.P.I. 36916	89		
Manchu	91		Y
Black Eyebrow	91	33.4	Y
S.P.I. 36901	91		
S.P.I. 36647	91		
Elton	92	34.3	Y
S.P.I. 36576 (Aksarben)	96		Y
S.P.I. 30745 (White Eyebrow)	99		Y
Check (Wilson 89)	102	31.4	Y
Ohio 9035 (Hamilton)	102	37.3	Y
Ohio 7490	102	12	
Ohio 9016	103		
Wilson	104	33.9	Y
Ebony	104	18.7	Y
Medium Green	105	34	
Habaro	106	13.6	Y
Haberlandt	109	15.6	Y
Mikado	109		Y
Royal	109	22.9	Y
Peking Sel 1-21-8	110	30	Y
1-21-5	110		Y
1-21-7	110	32	Y
S.P.I. 28051	110		
Sherwood	110	26.2	Y
Virginia	111	31.0	Y
Peking	111		Y
Peking Sel 1-21-3	111		
Shingto	111	46.6	Y
Chestnut	111	31.1	Y
Early Yellow	112	15.1	
American Coffee Berry	112	12.7	
Early Black	112	21.9	
Peking Sel 1-21-3	113	37.3	
Sable	115		
Wisconsin Black	115	21.0	
Medium Early Yellow	115	18.9	

SOYBEAN VARIETIES—AMERICAN—*continued.*

Variety	Average No. of days to mature.	Yield bus./acre.	Seed Colour.
Medium Early Brown	115	16.6	
Medium Early Black	115	12.0	
Ohio 7406	116	20.0	
Mongol	116	24.0	
Taha	117	46.6	
Jet	117	32.4	
Haberlandt	118	15.6	
Chernie	119	13.7	
Nuttall	119	14.2	
Ohio 7476	122	16.0	
Medium Green	124	15.0	
Amherst	134	15.9	
Mever	134	14.8	
Cloud	125	13.4	

CANADIAN SOYBEAN VARIETIES.

Variety	Average No. of days to mature.	Yield bus./acre.	Seed Colour.
St. Anne's No. 92	108	21.68	
Early Brown	109	25.9	Y
Mandarin	113	29.53	Y
Yellow 210	117	30.87	
Yellow 17	118	31.22	
Chinaton Echo	117	27.64	
Italian	119	30.19	
O.A.C. No. 211	121	33.78	
O.A.C. No. 81	117	28.71	
Summerland	119	23.94	
Black (China)	117	25.84	
Early Korean	123	35.48	
Green	122	34.25	Y
Manchu	123	34.88	Y
Black Eyebrow	122	34.96	Y
Ito San	123	29.60	Y
Golden	125	35.48	
A.K.	126	37.44	Y

Varieties grown experimentally in New Zealand and having an average yield of 23 bushels.—Early Yellow, O.A.C., Black Ontario, Manchu (Hudson), Manchu (Ottawa), Cayuga.

SOME EDIBLE VARIETIES OF SOYBEANS.

As Green Vegetable.—Agate, Hahto, Easycook, Rokusen, Funk Delicious, Kura, Aoda, Bansii, Shiro, Hokkaido, Chusei, Higan, Janro, Willoni, Nanda, Jogun.

Cooking Dried Beans.—Easycook, Chusei, Rokusen, Jogun, Hokkaido, Janro.

Fertilisers for Lettuces at York.

L. T. Jones and J. P. Eckersley.

SUMMARY.

WARTIME shortages of blood and bone manure have resulted in fertiliser difficulties with vegetable crops and particularly with the lettuce crop at York. As a result an experiment was carried out with this crop on a red-brown earth typical of the York gum and jam country at York, to demonstrate the satisfactory replacement of blood and bone manure with mineral fertilisers. The results and recommendations may be summarised as follows:—

(1) The primary fertiliser need for lettuces under these conditions was nitrogen.

(2) When using blood and bone manure only as a source of nitrogen, at least a ton per acre had to be used for satisfactory yields.

(3) All six mineral ("artificial") fertiliser treatments were as good or even better than one ton of blood and bone manure per acre.

(4) Potash had no beneficial effect in this experiment.

(5) With the autumn planted lettuce crop at York the "artificial" fertilisers could be applied in one application about one week after transplanting. It was not necessary to split the fertiliser into three applications, as is often advisable on sand country where leaching is severe.

(6) Two cwts. per acre of superphosphate plus three cwts. per acre of sulphate of ammonia (costing £3 10s. per acre) gave as good, or even better, results than one ton of blood and bone per acre (which costs £10 or more an acre and furthermore is now in very short supply).

(7) In this experimental lettuce crop, no evidence of fertiliser injury was observed, even when mineral fertilisers were used at the rate of 15 cwts. per acre. There was evidence that growers were confusing plant disease with fertiliser injury.

(8) The experiment indicated that, for lettuces, under these conditions, low rates only of mineral fertilisers were needed when chiefly nitrogenous fertilisers were used. The likelihood of fertiliser injury would be reduced by adopting a similar fertiliser practice.

(9) Blood and bone is a relatively inefficient form of nitrogenous fertiliser when compared with sulphate of ammonia under these conditions. The nitrogen content of one ton of blood and bone manure is approximately equivalent to six cwts. of sulphate of ammonia, yet an application of only three cwts. per acre of sulphate of ammonia gave equal or even better results than one ton of blood and bone manure.

It is apparent that under the continued shortage of the popular blood and bone manure the principles of the alternative use of the mineral, or so-called artificial fertilisers must receive increased consideration by the growers if vegetable production is to be increased or even maintained.

INTRODUCTION.

Complaints were received that mineral fertilisers could not be substituted for the generally used blood and bone manure and, in consequence, shortages in the supply of blood and bone manure were seriously limiting the area that could be cropped in the York market gardens.

In February, 1946, the authors paid a visit to the York market gardens and discussed with certain growers their fertiliser problems. Their main problem appeared to be the lettuce crop. They stated unanimously that lettuce could not be grown successfully unless a ton of blood and bone to the acre was used and that potato manure was no substitute for blood and bone manure for the lettuce crop. It should be noted that the blood and bone manure position had reached such a low ebb that the ration at the time was three cwt. per acre. With their other main crops growers were using potato manure to some extent.

The manuring of the lettuce crop, therefore, seemed to present greatest difficulties and the questions which required to be answered were—

(1) Can lettuces be grown successfully unless a ton of blood and bone manure to the acre is used?

(2) Is potato manure at 15 cwts. per acre a suitable fertiliser for the lettuce crop?

Growers reported the following effects of potato manure on the lettuce crop:—

(a) Although initially there is an obvious stimulation, growth later falls off and the lettuces "finish" poorly.

(b) Potato manure at 15 cwts. per acre is liable to cause fertiliser injury.

It was considered advisable to undertake demonstrations with mineral fertilisers to show that other fertilisers, when properly applied, could be satisfactorily substituted for blood and bone manure.

Previously many similar fertiliser experiments embracing six different vegetable crops had been completed in the metropolitan area, demonstrating that blood and bone manure could be replaced by artificial fertilisers when a properly balanced fertiliser mixture is used appropriate to the type of crop and the particular soil and climatic conditions.

SYSTEM OF MARKET GARDENING PRACTISED AT YORK.

York is situated 60 miles from Perth in a mixed farming district with cereals, sheep and pasture predominating. The York market garden produce has earned a place for itself on the Perth market because it can supply high quality vegetables at a time when the metropolitan supplies are deteriorating in quality. The produce is carted by motor transport to the Perth markets. The total annual rainfall is 17½ inches, of which 14½ inches falls in the winter months of May to October, inclusive. During the summer months the gardeners draw on the Goldfields Water Scheme to water their crops either by sprinkler irrigation or watering cans. They find it economic to pay for the scheme water at the rate of 1s. 6d. per 1,000 gallons. An area of up to 200 acres is cropped annually and about 30 growers are operating.

The gardens are situated mainly on the red-brown soils carrying York gum and jam. The soil generally has red-brown sandy loam to a foot deep, passing into red-brown clay.

What has been accomplished in this district indicates that practically any wheatbelt farmer can be a successful home gardener provided he has the requisite knowledge and a sufficient supply of good water.

THE FERTILISER PRINCIPLES INVOLVED.

It is necessary in the discussion of a fertiliser experiment of this nature to clearly understand the principles of manuring, so that the results will not be misinterpreted and applied to cases where they are inappropriate.

Although many elements are necessary for the growth of plants, it is found in practice that the soil supplies most of these in adequate amounts, except perhaps in the case of nitrogen, phosphorus, and potassium. Therefore maximum yields are often obtained when these three elements are supplied either singly or in combination in the form of a suitable fertiliser.

The factors governing a response to fertiliser (such as the initial soil fertility, the type of crop grown, the climate and the type and method of fertiliser application) are so variable as to make any general recommendation as to what is the best fertiliser to use a very difficult question, unless a sound and intimate knowledge of the conditions operating is obtained. Fortunately considerable latitude is permissible in the amounts and proportions of the different fertilisers that will result in satisfactory yields. The only sound method at present of finding out the exact fertiliser requirements of any particular crop under certain specific conditions is along the lines of many and varied, well-conducted, fertiliser trials.

The two popular fertilisers used in market gardening are blood and bone manure and potato manure and if we examine the composition and functions of these two manures we can provide ourselves with lessons in the principles of the correct use of fertilisers.

Blood and bone manure contains nitrogen and phosphorus and practically no potash. In market garden practice the special use of blood and bone is as a comparatively slow but lasting source of nitrogen. Being relatively insoluble it can be liberally applied to the ground and foliage without causing leaf "burn." Being a comparatively slow-acting form of nitrogen its excessive use will not induce potash deficiency as readily as the more soluble and quick-acting forms of nitrogen such as nitrate of soda, and sulphate of ammonia.

Potato manures in Western Australia generally contain nitrogen (as sulphate of ammonia), phosphorus (as superphosphate) and often in addition, potassium (as muriate or sulphate of potash).

Many growers prefer to buy the ingredients separately and make up their own mixtures which they believe from experience to be the best for that particular crop under their particular conditions.

Phosphate and potash are usually fairly well retained by the soil and are needed to a large extent early in the life of the plant. Nitrate, on the other hand, is easily leached out of the soil and is needed continually throughout the growth period.

A consideration of these principles allows us to make the general recommendation that potato manures or other complete mineral fertilisers should be applied at or about planting time, and depending on the needs of the crop, the weather, and the nature of the soil, further side dressings of nitrogen in the form of sulphate of ammonia or nitrate of soda should be applied if necessary.

The practical effects of the three fertiliser elements are briefly as follows:—

Nitrogen promotes leafy growth and is therefore of prime importance for such crops as lettuce and cabbage. In excess it may delay fruiting and maturity, favour certain diseases, and induce potash deficiency.

Phosphorus plays an important part in the general growth of the plant. It is most important early in the life of the plant and hastens fruiting and maturity.

Potassium.—A plentiful supply enhances the plant's ability to resist disease and adverse conditions. It is often an insurance against the bad effects produced by an excessive application of readily-soluble nitrogenous fertilisers.

AN ANALYSIS OF THE REPORTED FERTILISER PROBLEMS.

After discussions with the growers it became apparent that their fertiliser problems involved two factors, namely:—

1. *Nitrogen Nutrition.*—As blood and bone manure is regarded by the York market gardeners as the perfect fertiliser for their lettuce crop it is logical to examine the known properties of this manure in a study of their fertiliser problems. Many recent local fertiliser experiments with vegetables have indicated that in practice the main value of blood and bone as a fertiliser is as a comparatively slow but lasting source of nitrogen. If the main need at York for the lettuce crop is nitrogen, then the potato manure being used was a wasteful method of applying it.

The reported growth history of previous lettuce crops grown with potato manure suggested a nitrogen deficiency in the later stages of growth. It was the custom to apply 15 cwts. per acre of a certain potato manure. This supplied about 1 2/3rds cwts. per acre of the nitrogenous fertiliser, sulphate of ammonia, and the lettuces were not "finishing" under this treatment.

Therefore the evidence suggested that the nitrogen nutrition of this crop was inadequate.

2. *Fertiliser Injury.*—It was stated that potato manure at 15 cwts. per acre was responsible for fertiliser injury, by direct contact with the foliage and by root "burning." In the past, according to the growers, they were not worried by this problem when blood and bone manure was used. It is a fact that blood and bone manure, being comparatively insoluble, can be applied rapidly and safely, while the same methods used with soluble mineral fertilisers could result in fertiliser injury to the roots or foliage.

Foliage "burn" is due to allowing soluble fertilisers to lie on the leaves of sensitive plants, while fertiliser root injury is related to the concentration of the soil solution in contact with the roots as a result of heavy applications, or unsuitable placement of soluble fertilisers.

It is therefore obvious that where fertiliser injury is liable to occur its harmful effects can be minimised by—

(a) Keeping the soluble fertilisers as much as possible off the foliage.

(b) Adopting a suitable method of fertiliser placement.

(c) The judicious use of sprinkler irrigation where this is available.

THE SELECTION OF EXPERIMENTAL TREATMENTS AND CROP.

In the light of the possible effect of the two factors discussed above an experimental design was worked out for a lettuce crop embodying the principles previously discussed.

The lettuce crop was chosen because the growers considered that this crop could not be grown successfully with potato manure. It was believed that if mineral fertilisers could be used satisfactorily with this reputedly sensitive crop

it would amply demonstrate their suitability for the more hardy crops, such as cauliflower and celery, if suitable manurial methods were adopted.

Previous experience suggested that three cwts. per acre of sulphate of ammonia would be a satisfactory nitrogenous fertiliser dressing for this crop under the circumstances. If insufficient in one application, because of losses by leaching, this rate should at least prove sufficient if applied in three equal fortnightly applications.

Potash, at two cwts. per acre, was considered sufficient, if a potash deficiency was operating. Muriate of potash was used in preference to sulphate of potash because muriate is more liable to cause fertiliser injury than is sulphate.

Superphosphate, at the rate of 10 cwts. per acre, was added to make the total fertiliser mixture up to 15 cwts. per acre on the assumption that, if 15 cwts. per acre of potato manure was causing fertiliser injury, then it would also occur with this rate of complete fertiliser mixture.

Thus the basic experimental mineral fertiliser mixture selected was:—

Sulphate of ammonia (20 per cent. N)	3 cwts. per acre
Superphosphate (18 per cent. P_2O_5)	10 cwts. per acre
Muriate of potash (60 per cent. K_2O)	2 cwts. per acre
Total application rate	15 cwts. per acre

The composition of this basic experimental mixture is 4 per cent. nitrogen (N), 12 per cent. phosphoric acid (P_2O_5), and 8 per cent. potash (K_2O).

Also, it was considered that under these conditions, it might be possible to omit from the complete fertiliser mixture those components that are not essential for increased growth and also thereby limit the possibility of fertiliser injury. For instance, superphosphate and/or potash might not be necessary for this particular crop on this fertile soil in the light of its previous fertiliser history.

It was decided that the treatments derived from this basic application of 15 cwts. per acre of mixed fertiliser should be applied in one and three applications, so that reduced rates of application could be tried for its effect on possible fertiliser injury, and also the principle of split applications of nitrogenous fertilisers could be investigated under these particular conditions. Two treatments would therefore have been three cwts. of sulphate of ammonia only, in one and three applications, but it was later considered advisable to include two cwts. of superphosphate per acre with these two treatments to guard against the possible need for some readily available phosphate.

Because of the acute shortage of blood and bone manure the rationing authorities found it necessary about the time of this experiment to ration this fertiliser at the rate of three cwts. for each acre of certain priority crops planted. It was not contended that this ration in itself was sufficient but rather was it a method of fair distribution. The growers were urged to supplement their blood and bone ration with artificial fertilisers and fertiliser experiments with a variety of crops were conducted to demonstrate that mineral fertilisers, when applied correctly, could replace the usual heavy rates of blood and bone manure. Thus two obvious treatments in this case were blood and bone manure at three cwts. and 20 cwts. per acre. A treatment consisting of blood and bone manure at 10 cwts. per acre was also included because this supplied organic nitrogen equivalent to the inorganic nitrogen contained in three cwts. of sulphate of ammonia.

In order to have some measure of the inherent soil fertility a no-fertiliser treatment was also tried.

In consequence the ten experimental fertiliser treatments for this lettuce crop were as follows:—

Experimental Fertiliser Treatments.

Treatment A.—No fertiliser.

Treatment B.—Blood and bone manure at three cwts. per acre, applied one week after transplanting.

Treatment C.—Blood and bone manure at 10 cwts. per acre, applied one week after transplanting.

Treatment D.—Blood and bone manure at 20 cwts. per acre, applied one week after transplanting.

Treatment E.—A complete artificial fertiliser mixture applied at the rate of 15 cwts. per acre, one week after transplanting and containing—

Sulphate of ammonia	3 cwts. per acre
Superphosphate	10 cwts. per acre
Muriate of potash	2 cwts. per acre

Treatment F.—Same as treatment E but applied in three equal dressings of five cwts. per acre—

(a) One week after transplanting.

(b) Three weeks after transplanting.

(c) Five weeks after transplanting.

Treatment G.—Treatment E minus potash—

Sulphate of ammonia	3 cwts. per acre
Superphosphate	10 cwts. per acre

applied in one application one week after transplanting.

Treatment H.—Same as treatment G, but applied in three equal dressings of 4 1/3rd cwts. per acre—

(a) One week after transplanting.

(b) Three weeks after transplanting.

(c) Five weeks after transplanting.

Treatment J.—Sulphate of ammonia as in treatment G, but superphosphate reduced to two cwts. per acre—

Sulphate of ammonia	3 cwts. per acre
Superphosphate	2 cwts. per acre

applied in one application one week after transplanting.

Treatment K.—Same as treatment J, but two cwts. per acre of superphosphate applied at first application and sulphate of ammonia applied in three equal dressings of one cwt. per acre each—

(a) One week after transplanting.

(b) Three weeks after transplanting.

(c) Five weeks after transplanting.

THE EXPERIMENTAL SITES AND LAYOUT.

It was originally planned to conduct full scale fertiliser experiments with lettuces on three different properties. Two of these sites would have been laid down on the typical red-brown soil of the York gum and jam country which is the main soil type used for vegetable growing at York. The third site was on soil of limited occurrence, being a grey-brown gritty, loamy sand occurring as a tongue of seepage or moister soil coming away from a rock outcrop.

Later, however, it transpired that it was not convenient for one of the co-operating growers to undertake an experiment, while another could only accommodate a trial of two replications.

Fortunately Messrs. Kodra Bros., who specialise in large-scale lettuce culture, were able to provide a suitable site for an experiment consisting of 10 treatments replicated six times, using the randomised block method of layout. The site was representative of a large proportion of the York market gardens, having originally carried York gum and jam and the soil being described as a red-brown gritty sandy loam to approximately 12 inches on to red-brown clay. Therefore in the first week in April, six adjacent beds, each one chain long, of newly transplanted lettuce were reserved amongst the commercial crop on this property for a fertiliser experiment.

Mr. N. Hassen was able to provide from amongst his commercial crop two beds of transplanted lettuce seedlings so that in this case the experiment of 10 treatments could only be duplicated. The soil at this site is a grey-brown gritty loamy sand, forming part of a seepage channel below a rock outcrop. This soil is lighter in texture than the typical York gum and jam country, and would normally be judged as less fertile. However, this site had been very heavily manured in the past with dressings of horse manure.

The two growers concerned supplied the planted experimental sites and undertook the necessary sprinkler irrigation, weeding, and cultivation, while the Department of Agriculture supplied and applied the calculated amounts of the appropriate fertilisers and manures for each numbered plot, consisting of five rows each containing five lettuce plants.

The fertilisers were applied as surface bands four inches wide down the centre of each row, then lightly cultivated in, and finally watered in with the sprinklers. Reasonable care was taken to see that as little as possible of the fertiliser

lodged on the foliage. This procedure was not as rapid as the usual method of applying blood and bone manure but there is no doubt that under commercial conditions a rapid technique could soon be evolved. Machine distribution of fertiliser should be helpful in this regard.

OBSERVATIONS DURING GROWTH.

At regular intervals during growth a comparative assessment of vigour was made on each of the plots. Points were allotted to represent the visual differences in vigour of the lettuces in the various plots.

1. *N. Hassen's Amended Experiment.*—As an experiment the amended trial on this property was unsatisfactory although the lettuces produced were of high quality. Stock broke in and ate and trampled on many of the lettuce plants, thus making any estimates of yield unreliable. For this reason the lettuces in this experiment were not cut and weighed to provide yield data.

The observations made during the growth of this experimental crop indicated that there was no difference between any of the treatments. That is, no fertiliser was as good as the heaviest rates applied. It appears that the built-up fertility of the soil was such as to allow of no extra benefit when additional fertilisers were used.

It should be noted, however, that no obvious symptoms of fertiliser injury were recorded even where high rates of artificial fertilisers were applied.

2. *Kodra Bros'. Full-scale Experiment.*—The cultural details of this experiment are as follows:—

Lettuce Variety—"Imperial D."

Seedlings transplanted, 4th April, 1946.

First application of fertiliser, 12th April, 1946.

Second application of fertiliser, 26th April, 1946.

Third application of fertiliser, 7th May, 1946.

Lettuces harvested, 11th June, 1946.

The method adopted, in assessing the relative vigour of each plot, was for the grower himself to grade the lettuces without any reference to a plan of the experiment. The complicated nature of the experiment (there being sixty plots with the 10 treatments scattered at random within each of the six blocks) ruled out the possibility of memorising the treatment of any particular plot so that personal bias could not enter into the grade awarded to any treatment. In the absence of Mr. Kodra, the authors themselves conducted the assessment along the same lines.

It was initially suggested that the grower confine himself to five classes and the following terms were used: bad, poor, medium, good, and very good. On this basis of classification, in order to simplify the tabulation of results, points were allotted for the five classes, namely, 2, 4, 6, 8 and 10. Where a plot was judged as lying between two classes it was assessed as the appropriate odd number. As there were six plots to each treatment the maximum possible score was 60.

The results of this method of grading are summarised in Table I.

Table I.

FERTILISER EXPERIMENT WITH LETTUCES—KODRA BROS., YORK—APRIL-JUNE, 1946.

Summary of Grading Points.

(Maximum Possible Score—60.)

Treatment.	26–4–46.	7–5–46.	15–5–46.	23–5–46.	30–5–46.	Harvest, 11–6–46.
A. No fertiliser	22	16	16	14	14	*17
B. Blood and bone, 3 cwts. per acre	34	24	23	23	26	*32
C. Blood and bone, 10 cwts. per acre	34	28	31	29	32	*34
D. Blood and bone, 20 cwts. per acre	38	44	39	41	43	42
E. 10 cwts. super., 3 cwts. sulphate of ammonia, 2 cwts. muriate of potash, in 1 application ...	40	50	50	50	43	42
F. 10 cwts. super., 3 cwts. sulphate of ammonia, 2 cwts. muriate of potash, in 3 equal applications	38	38	39	43	46	45
G. 10 cwts. super., 3 cwts. sulphate of ammonia, in 1 application	40	46	47	50	46	46
H. 10 cwts. super., 3 cwts. sulphate of ammonia, in3 equal applications	38	38	35	41	41	43
J. 2 cwts. super., 3 cwts. sulphate of ammonia, in 1 application	44	50	50	53	46	46
K. 2 cwts. super., in 1 application, 3 cwts. sulphate of ammonia in 3 equal applications ...	34	34	36	38	39	44

* Favoured by inclusion of buffer rows.

Note.—No time was available to make a grading of the plots before harvesting commenced. To remedy this omission a set of figures was estimated from the gross returns per acre on the basis of a grading of 46 for the maximum monetary yield.

DISCUSSION OF TABLE I.

Table I illustrates, by means of points allotted for vigour during the progress of the experiment, and for yield at harvest time, the effects of the six different rates and methods of applying nitrogenous fertilisers. The figures show that—

1. The no-fertiliser treatment as a commercial crop was a failure. The comparative vigour declined during the experiment and the lettuces were a pale green colour.

2. Blood and bone manure at three cwts. per acre did not supply sufficient nitrogen for satisfactory growth. The plants were pale in colour and compared with the treatments receiving adequate nitrogen the difference in growth became progressively worse from a few weeks after transplanting until harvest time.

3. Blood and bone manure at 10 cwts. per acre still did not supply sufficient nitrogen for satisfactory growth. This treatment resulted in a pale green foliage but gave more vigorous lettuces than those in the two previous treatments. However, the crop produced did not reach satisfactory commercial standards.

4. Blood and bone manure at one ton per acre gave fairly vigorous growth at all stages and produced a good commercial crop.

5. Those treatments receiving three cwts. per acre of sulphate of ammonia, as one application a week after transplanting, were initially very vigorous and finally produced a good commercial lettuce.

6. Where three cwts. per acre of sulphate of ammonia was applied in three equal split dressings, it was found that although growth in the early stages was relatively backward, the lettuces later improved rapidly and continued on to produce a good commercial crop. Therefore sulphate of ammonia at the rate of one cwt. per acre gave, apparently, an insufficient supply of nitrogen in the early stages of growth. It was not until the full effect was felt of the two subsequent fortnightly side-dressings that these treatments caught up with those receiving three cwts. per acre of sulphate of ammonia, a week after transplanting.

THE HARVESTING OF KODRA BROS'. EXPERIMENT.

Originally it was planned to cut only the centre lettuces of each plot and discard the buffer rows, but as these methods would have interfered with the grower's harvesting operations, yield data was finally obtained from a complete plot of 25 lettuces.

It was observed during the growth of the experimental lettuces that the buffer rows (the outside lettuces adjacent to another fertiliser treatment) in treatment A (no fertiliser), treatment B (three cwts. per acre of blood and bone), and treatment C (10 cwts. per acre of blood and bone) had obviously benefited by feeding into the fertiliser supplies of the adjacent treatments. This was not the case with the other seven treatments because at harvesting time they presented a fairly uniform appearance throughout the plot.

Thus the harvest figures presented in Table II favour the first three treatments which would have made an even poorer showing had the outside buffer rows been discarded. Fortunately this does not detract from the purpose of the experiment because the yield data, even as presented, provide sufficient evidence to demonstrate the fertiliser principles involved.

The harvested lettuces were marketed as "Fancy" and "1st Grade" and the prices obtained on a favourable market were 6s. 6d. a dozen for "Fancy" and 4s. a dozen for "1st Grade." It was then estimated what would have been the gross return per acre for each particular treatment. These figures have been added to the harvesting data in Table II. The lettuce plants were so spaced as to give 35,000 lettuces to the acre, inclusive of paths. It is not suggested that these prices are average returns, but they do at least provide comparable figures and have the added advantage that they are the actual market prices obtained.

An examination of the yield data indicates that in this particular instance the grading into "Fancy" and "1st Grade" was largely a matter of relative weights. Naturally, the heavier the lettuce the greater would be the size and density of the heart. When stripped ready for market, the average weight of a "Fancy Grade" lettuce was one pound nine ounces, while the average weight of a "1st Grade" lettuce was one pound two ounces.

The lettuces shown in the table as "not cut" consist of "rejects" unfit for sale and a small proportion which were cut on 20th June and which, despite the extra growth time allowed, could only reach "2nd Grade." For the sake of clarity these second cuts, which do not materially affect the results, were omitted from the table.

TABLE II.

FERTILISER EXPERIMENT WITH LETTUCES -KODRA BROS., YORK—APRIL-JUNE, 1946.

Yield Data—Harvested 11th June 1946.

Yield from 6 plots of 25 Lettuces = 150 Lettuces.

Treatment.	Fancy Grade.		1st Grade.		Total Cut.		Lettuces not Cut.	Lettuces which died.	Gross Return.
	Number.	Weight.	Number.	Weight.	Number.	Weight.			
		lb. ozs.		lb. ozs.		lb. ozs.			per acre.
A. No fertiliser	26	40 0	37	40 7	63	80 7	87	....	£310
B. Blood and bone, 3 cwts. per acre	64	97 15	45	50 2	109	148 1	38	3	£580
C. Blood and bone, 10 cwts. per acre	61	90 15	61	69 2	122	160 1	26	2	£625
D. Blood and bone 1 ton per acre	100	156 7	34	38 3	134	194 10	12	4	£765
E. 10 cwt. super., 3 cwt. sulphate of ammonia 2 cwt. muriate of potash per acre—in 1 application	98	151 2	40	43 8	138	194 10	9	3	£775
F. As treatment E, but in 3 applications	120	192 14	19	21 9	139	214 7	10	1	£830
G. 10 cwt. super., 3 cwt. sulphate of ammonia, in 1 application	117	183 13	26	27 12	143	211 9	5	2	£840
H. As treatment G, but in 3 applications	102	161 15	39	45 11	141	207 10	8	1	£795
J. 2 cwt. super., 3 cwt sulphate of ammonia, in 1 application	122	187 6	20	21 10	142	209 0	6	2	£84.
K. 2 cwt. super., in 1 application plus 3 cwt. sulphate of ammonia in 3 applications	109	173 10	29	32 4	138	205 14	11	1	£800
Difference necessary for significance P 05	....	52 3	....	....	....	39 6	....	....	....

DISCUSSION OF TABLE II.

Nitrogen.

It is obvious from the tabulated results that nitrogen was the primary fertiliser need for the lettuce crop under those conditions. When using blood and bone as the only source of nitrogen at least a ton per acre was needed for satisfactory yields. Under those conditions the three cwt. of sulphate of ammonia could be applied in one application about a week after transplanting and it is not necessary to split the nitrogenous fertiliser into three applications, as is the case on Perth sand under sprinkler irrigation, where leaching is severe. In this experiment the nitrogen content of blood and bone manure was not more than half as efficient as the nitrogen content of sulphate of ammonia. Although the arbitrarily decided rate of three cwt. per acre of sulphate of ammonia proved satisfactory in this experiment, it should not be concluded that this is the optimum rate as further trials may show that higher yields are obtained when greater applications are used.

Phosphate.

The results indicated no improvement from increases above two cwts. per acre of superphosphate. However, this result should be interpreted with caution as the past fertiliser history of this soil may have built up a high phosphate

status. This and other similar evidence throw doubt on the need for high rates of superphosphate with many of our vegetable crops when planted on "old land" which has received considerable amounts of phosphatic fertilisers in the past.

Potash.

Although the inclusion of potash in the fertiliser mixture had no beneficial effect in this experiment, it may become necessary to add potash if continual cropping, without it, is practised. The need for potash may also be accentuated if the readily soluble nitrogenous mineral fertilisers, nitrate of soda and sulphate of ammonia, are used too liberally.

Fertiliser Injury.

In this autumn-planted experimental lettuce crop, no evidence of fertiliser injury was observed even with the highest rates of application. However, it should be remembered that all reasonable precautions were taken to guard against its occurrence. The fertilisers were applied carefully in order that as little as possible fell on the leaves and a form of band-placement of fertiliser was practised.

During the course of the experiment attention was drawn to some lettuce plants which were dying and which the growers attributed to fertiliser "burn." Samples of these affected lettuces were submitted to the Plant Pathologist who diagnosed the disease as "Lettuce Drop," which appears to be very prevalent in this area during the wet winter months. Practically all the deaths, as reported in Table II, can be attributed to this fungal disease.

It is of interest to note, in view of some of the published statements regarding the respective merits of organic manures and artificial fertilisers that the evidence of this trial does not support the contention that the use of artificial fertilisers favours the incidence of disease.

RESULTS OF EXPERIMENT IN RELATION TO FERTILISER PROBLEMS.

The fertiliser experiment conducted on Messrs. Kodra Bros. property has given complete answers to the fertiliser problems submitted by the York market gardeners. They are as follows:—

1. *Rates of Blood and Bone Manure Necessary.*—If blood and bone manure is used as the sole source of nitrogen with the lettuce crop, then under these conditions it is necessary to use about a ton per acre for satisfactory yields. It can then be appreciated that while blood and bone manure is in short supply it is incumbent upon the growers to augment the ration available by using such mineral nitrogenous fertiliser as nitrate of soda, or sulphate of ammonia. The principles underlying the use of these fertilisers are discussed in this article.

2. *Fertiliser Injury.*—Fertiliser injury was not observed in this experiment. However, the procedure to be followed to minimise the likelihood of fertiliser injury has been discussed and if reasonable precautions are taken there should be no trouble even with relatively heavy applications. Furthermore, the experimental results show that low rates only of artificial fertilisers are needed when chiefly nitrogenous fertilisers are used, so that the possibility of fertiliser injury can be still further reduced by adopting a similar fertiliser mixture.

3. *The Use of Potato Manures with the Lettuce Crop.*—The original complaint was that potato manure at the rate of 15 cwts. per acre could not be successfully substituted for one ton of blood and bone per acre. As it has been

established by this experiment that the primary fertiliser need for this crop was nitrogen, the nitrogen contents of the potato manures used are now examined, in order to assess their value for this crop.

ANALYSIS OF POTATO MANURES A AND A_2.

Constituent.	A.	A_2.
Phosphoric acid (P_2O_5)	13·00%	11·56%
Nitrogen (N)	2·50%	2·23%
Potash (K_2O)	5·00%	4·45%

Note.—A_2 was substituted for A from 15th March, 1945.

The growers stated that they applied potato manures A or A_2 at the rate of about 15 cwts. per acre with poor results on their lettuce crop. Using them they were unable to produce a "finished" lettuce. At the rate of 15 cwts. per acre, potato manure A would supply 1.8 cwts. per acre of sulphate of ammonia, while potato manure A_2 would supply 1.6 cwts. per acre of sulphate of ammonia. The experimental results indicated that the nitrogen supplied by three cwts. of sulphate of ammonia was a satisfactory amount and therefore the lettuce grower, to apply this amount, would need to use potato manure A at the rate of 25 cwts. per acre and potato manure A_2 at the rate of 28 cwts. per acre. Therefore, it will be appreciated that the use of these potato manures is an inefficient method of supplying nitrogen to the lettuce crop. Had the growers been aware of the nitrogen deficiency symptoms in the lettuce crop they could have "finished" the plants, even after the initial use of potato manure, with a side dressing of nitrate of soda or sulphate of ammonia, at the rate of one to two cwts. per acre. Under the fertiliser rationing scheme extra supplies of nitrate of soda were available for side-dressing purposes.

This finding will no doubt have an application to other vegetable crops, especially where in some instances the grower claims beneficial results from exceptionally heavy applications of potato manure.

CONCLUSION.

The experiment furnishes further evidence of the fact that blood and bone manure can be replaced in vegetable growing provided a suitable mineral fertiliser mixture is applied in a manner suitable for that particular crop, climate, and soil. It had been argued that although this contention might hold good for the metropolitan area, it would not operate successfully with a lettuce crop under York conditions. The experimental evidence shows that artificial fertilisers, when properly applied, will result in satisfactory vegetable crops in the York district as well as in the metropolitan area.

It is felt that where there is a reluctance to use mineral fertilisers freely, the proper use of superphosphate, sulphate of ammonia or nitrate of soda and potash are not fully understood. Therefore the opportunity was taken in reporting this experiment to discuss more fully than would otherwise have been warranted some important aspects of plant nutrition, and to use these experimental results as illustrations, wherever possible, of the basic principles of manuring in the hope that many growers would profit from the discussions and would thereby gain a fuller understanding of their fertiliser problems.

ACKNOWLEDGMENTS.

These experiments were conducted as a co-operative effort by the Plant Nutrition and Vegetable Branches of the Department of Agriculture.

Thanks are expressed to Messrs. Kodra Bros. and Mr. N. Hassen for making available experimental sites amongst their commercial crops and for their valuable assistance in the conduct of the experiments. Also thanks are due to the Conservator of Forests, Mr. T. N. Stoate, for the statistical analysis of the results.

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1945-1946 Experiments with D.D.T. and 666 as Agricultural Insecticides.

C. F. H. Jenkins, Government Entomologist.

P. N. Forte, Assistant Entomologist.

D.D.T.

E.M.N

THE use of D.D.T. or dichloro-diphenyl-trichloroethane as an insecticide ranks as one of the outstanding discoveries of the war period for, although the material was first prepared by a German chemist in 1874, it was not until 1939 that its vast potentialities as an insecticide were foreshadowed.

TOXICITY OF D.D.T.

D.D.T. is a contact as well as a stomach poison and unlike other insecticides in common use has the advantage of remaining effective as a spray or dust film for a considerable period. It is slow in action, however, and signs of distress may not be noticeable in an insect for half an hour or more after receiving a lethal dose while death may be delayed for a much longer period.

D.D.T. is toxic to mammals and consequently should be handled with care. Oil solutions are readily absorbed through the skin and therefore are unsuitable for the treatment of animals excepting under special circumstances. Dusts and emulsions are much safer and are available in forms suitable for use both on plants and domestic animals.

D.D.T. is highly toxic to fish and many other cold-blooded creatures.

D.D.T. RESIDUE ON FOODSTUFFS.

Although D.D.T. is regarded as less dangerous than many other insecticides in common use every care should be taken to prevent the accumulation of residues on vegetables and other foodstuffs. No definite tolerance limit is at present given for this State but a tentative figure fixed in the U.S.A. is seven parts per million.

The likelihood of heavy residues accumulating on vegetables such as cabbages has been investigated and the report of the Government Analyst outlined in the accompanying table shows that the residue remaining after cooking or after the useless outer leaves have been discarded is very small. At the present stage of our knowledge, however, it would be unwise to treat liberally mature lettuce or similar foodstuffs which might later be eaten with much of the residue still present.

TABLE I.—RESIDUE OF D.D.T. ON CABBAGES.

Cabbage No.	1.	2.	3.
Portion Examined ...	Heart (outer leaves discarded)	Whole Vegetable (outer leaves included)	Whole Vegetable.
D.D.T. In Raw Sample (p.p.m.)	Less than 7 ...	40	19
D.D.T. in Cooked Sample (p.p.m.)	Less than 7 ...	Less than 7 ...	Not determined

No. 1 and 2 consisted of cabbages of normal growth with hard, compact hearts.

No. 3 consisted of a cabbage with open leaves and no compact heart.

Seven parts of D.D.T. per million constitutes the lower limit which could be estimated on the quantity of material available.

PLANT INJURY.

No obvious plant injury was found associated with any of the experiments here outlined although investigations elsewhere have shown that certain plants such as young beans and melons are susceptible to some types of D.D.T. preparations. A reduction in yield from tomatoes treated with one per cent. dust has also been reported but in local experiments no such detrimental effects have been noticed.

EFFECT ON BEES AND OTHER USEFUL INSECTS.

D.D.T. is known to be toxic to bees as well as many other useful insects, but the same applies to many insecticides and this is not a sufficient reason for condemning the use of this new material. Bees are most vulnerable when blossoming plants are treated and usually dust and spray applications can be timed to avoid the blooming period.

In addition, it is of interest to note that in Germany field dustings with D.D.T. and arsenate of lead have shown that bees could withstand treatments three times the necessary strength of D.D.T. required to control rape beetle, but were killed with the minimum application of arsenate of lead.

It is doubtful whether the various pessimistic forecasts concerning the adverse effect of D.D.T. upon the balance of nature are well founded. Local upsets may occur as is instanced in the present paper where a high proportion of Bryobia mite developed on apple trees successfully treated for the control of the apple leafhopper. Dual purpose mixtures are being developed to meet some of these difficulties however, and it is claimed that white oil added to certain D.D.T. emulsions will control both leafhopper and mite.

It must not be conceived that D.D.T. will be used in a wholesale manner over the countryside to kill friend and foe alike as such an unrestricted slaughter might be fraught with dire results.

Used on comparatively small areas such as orchards and gardens, however, the effects would be very local and should be easily adjustable by future action.

PESTS TREATED WITH D.D.T.

Except where otherwise stated a 1 per cent. D.D.T. pyrophyllite dust and a 0.1 per cent. D.D.T. emulsion were the preparations used in the following experiments:—

Rutherglen Bug (*Nysius vinitor*).

Dust and spray treatments were applied to several infested plots of potatoes but no appreciable reduction in the bug population was effected.

Experimental work in the Eastern States has shown that under certain conditions satisfactory control of this pest can be obtained with D.D.T. preparations, but tests over two seasons have given negative results locally.

Apple Leafhopper (*Typhlocyba froggatti*).

A block of trees in a heavily infested Bridgetown orchard was sprayed late in November at the rate of two gallons per tree. Within 24 hours the trees were practically free of leafhoppers and no serious re-infestation had occurred in February despite the fact that adjacent untreated trees carried a high population.

A disappointing aspect of this treatment was the rapid build-up of Bryobia mite (*Bryobia praetiosa*) on the treated trees.

Vegetable Leafhopper (*Empoasca terra-reginae*).

A block of 180 tomato plants treated at approximately 10-day intervals was kept practically free of this pest while control plots were heavily infested. Treatments on potatoes and melons proved equally successful.

Cabbage Aphis (*Brevicoryne brassicae*).

No effective control of this pest was obtained with either dust or spray treatments.

Black Citrus Aphis (*Toxoptera aurantii*).

It was not possible to conduct controlled experiments against this pest but in the absence of nicotine sulphate, many growers sprayed with D.D.T. during a severe aphis outbreak in the spring of 1946. An inspection of several orange groves shortly after the treatment indicated that D.D.T. was toxic to this species of aphis and that satisfactory control could be obtained from D.D.T. sprays.

Scale Insects.

Spray treatments were applied to citrus trees heavily infested with White Wax Scale (*Ceroplastes destructor*), Black Scale (*Saissetia oleae*) and Red Scale (*Aonidiella aurantii*). The sprays were applied just prior to the main emergence of the crawlers in the hope that the D.D.T. film would inhibit the settling down of the young. These treatments gave no better results, however, than those applied at the time of maximum crawler activity the previous season when no success was obtained.

Plate 1. Cabbages being dusted with a hand rotary duster.

Little Plague Grasshopper (*Austroicetes cruciata*).

The following formula was tested against grasshoppers in the Eastern Wheatbelt:—

10 per cent. D.D.T. pyrophyllite powder ..	1 lb.
Bran	24 lbs.
Molasses	6 lbs.
Water	2½ galls.

The results obtained were very similar to those associated with the arsenite of soda bait both being slower in action than the 666 mixture.

Apple Curculio (*Otiorrhynchus cribricollis*).

Two blocks of apple trees were sprayed with 0.1 per cent. D.D.T. emulsion. In one case the entire trees were sprayed; in the other, the trunks and lower limbs only were treated. The results were inconclusive as there was little weevil activity following the time of treatment on sprayed or unsprayed trees.

Argentine Ant (*Iridomyrmex humilis*).

The following treatments were applied in a citrus orchard carrying a heavy scale and ant population. The trees were all pruned so that none of the branches could touch the ground.

Hessian Bands.—Hessian bands about 12 inches wide saturated with 20 per cent. D.D.T. emulsion tied around the butts of the trees proved effective in preventing the ants climbing to the scale infested branches. Care was necessary to see that the bands were in contact with the trees all the way around as in several instances ants were found crawling up between the trunk and the bandage.

D.D.T. Paste Bands.—Bands consisting of a water paste of 3 per cent. and 5 per cent. D.D.T. on pyrophyllite proved ineffective.

Plate 2. Spraying main trunks of lemon trees with D.D.T. for control of Argentine Ants.

D.D.T. Sprays.—Sprays were all made from D.D.T. emulsion and were applied with a knapsack spray pump so as to saturate the trunk and lower limbs up to three feet six inches from the ground.

1 *per cent. D.D.T. Emulsion.*—Ants infesting sprayed trees were rapidly killed and the trees remained free of ants for seven weeks and up to 14 weeks later a very light infestation only was in evidence.

0.5 *per cent. D.D.T. Emulsion.*—Controlled infestation and kept trees clean for five weeks, then ant population gradually increased.

0.1 *per cent. D.D.T. Emulsion.*—Controlled ants for three weeks followed by a gradual build up of numbers.

It seems possible that the colonies usually infesting the trees used in the experiment were completely killed out and that as the effect of the D.D.T. residue gradually decreased, reinfestation occurred.

The use of D.D.T. sprays in preventing household invasions has been found equally effective.

House and Stable Flies (*Musica domestica and Stomoxys calcitrans*).

A suburban dairy which carried a very high fly population of the above species was selected to try the usefulness of D.D.T. on these pests.

A 4 per cent, solution of D.D.T. in power kerosene was used and one cow in 10 was sprayed on the legs and shoulders while in the bail. To avoid possible injury to the skin, the spray was applied as a mist which settled in fine droplets on the hairs and did not saturate the hide. The same cows were treated each time and treatments were given twice a week. Several selected places on the walls of the milking shed were also sprayed.

This treatment rapidly reduced the population of both species of flies to low proportions.

Observations made at the same dairy several weeks after the treatment ceased showed that the fly population was returning to the pre-treatment level.

Buffalo Fly (*Siphona exigua*).

Tests for the control of buffalo fly on cattle were carried out at Broome in August when flies, although not at their maximum, were sufficiently numerous for experimental purposes.

Three proprietary preparations were used, viz., Benzophen, Benzophen plus D.D.T. and "Rucide."* Benzophen has been used for many years past to treat all beasts shipped South from North-West ports. Both the D.D.T. mixtures were used at .5 per cent. concentrations and proved more effective than Benzophen alone but "Rucide" was superior to the other two and beasts sprayed with this preparation remained free of flies for 12 days after which period no further observations were taken.

*A proprietary D.D.T. preparation.

Cabbage Moth (*Plutella maculipennis*).

Two patches of cauliflowers each of 1,050 plants grown under sprinklers were treated at 10-day intervals one with 0.1 per cent. D.D.T. emulsion and the other with 1 per cent. D.D.T. pyrophyllite dust. Complete control of cabbage moth caterpillars was obtained with both treatments.

Climbing Cutworm (*Heliothis armigera*).

Two acres of mature flax were dusted with a Y2 Powderdust at the rate of 25 lbs. per acre. The caterpillar population before treatment was 12-15 per square feet and severe seed losses were being caused.

Injury had already occurred to the patch selected for treatment as for uncontrollable reasons the dusting was a little late. Further injury was prevented by one treatment, however, and the comparative seed yield may be estimated from the accompanying illustration.

Plate 3. Undusted and dusted sheaves of flax showing difference in cutworm injury.

A block of 180 tomato plants was dusted at approximately 10-day intervals and complete protection against cutworm injury was obtained.

False Looper Caterpillar (*Phytometra argentifera*).

A variety of heavily infested crops including potatoes, lettuce, silver-beet and cabbages was dusted and sprayed against this pest and a very satisfactory control was obtained.

Cabbage Butterfly (*Pieris rapæ*).

Results similar to that outlined for cabbage moth.

Red-Legged Earth Mite (*Halotydeus destructor*).

Preliminary experiments with 1 per cent. D.D.T. dust gave good control of this mite. Trials were carried out on seedling flax plants and young garden peas. The plants and surrounding soil were lightly dusted and two hours later the mites present were nearly all incapacitated. The following day only a few live mites could be detected although dead ones were plentiful. Three days later, no live mites could be detected and the crop matured without further mite injury.

Cattle Tick.

No special tests were carried out but indications were that 0.5 per cent. "Rucide" when used against the Buffalo fly was also effective against cattle tick.

"GAMMEXANE" Or 666.

666, Gammexane or Benzenehexachloride like D.D.T. is not a new substance having been made by Michael Faraday as far back as 1825 but it was not until 1941 that intense research by British chemists showed it be a worthy competitor with D.D.T. and for certain purposes unequalled.

TOXICITY OF "GAMMEXANE."

The effect of "Gammexane" upon the insect is very similar to that produced by D.D.T. The material is much less toxic to the higher animals, however, and so is superior to D.D.T. for certain purposes.

From the following results it will be seen that "Gammexane" proved ineffective against a number of local pests. Spray treatments proved superior to dusting, however, where the two were applied under similar conditions and the great difference between the efficiency of the two treatments indicates that there is ample scope for investigation into the preparation of mixtures and the methods of application.

PLANT INJURY.

No plant injury resulting from the use of "Gammexane" was detected following any of the treatments applied.

PESTS TREATED WITH 666.

Rutherglen Bug (*Nysius vinitor*).

Two rows 200 ft. long of well grown potatoes were used in the experiment, one area being dusted with 2 per cent. "Gammexane" dust and the other being sprayed with 0.2 per cent. "Gammexane" emulsion. No effect could be observed on the bug infestation.

Apple Leafhopper (*Typhlocyba froggatti*).

A block of trees in a heavily infested Bridgetown orchard was sprayed in late November at the rate of two gallons per tree with 0.15 per cent. "Gammexane" emulsion. No reduction in the leafhopper population could be detected.

Vegetable Leafhopper (*Empoasca terra-reginæ*).

Tomatoes infested with leafhopper were dusted with 2 per cent. "Gammexane" dust at fortnightly intervals but this failed to reduce leafhopper damage.

Scale Insects.

The tests made with "Gammexane" against scale insects were similar to those outlined under the heading of D.D.T. and equally disappointing results were obtained.

Cabbage Aphis (*Brevicoryne brassicae*).

No apparent control was obtained by the use of 2 per cent. "Gammexane" Dust

Little Plague Grasshopper (*Austroicetes cruciata*).

The following formulae were tested against grasshoppers in the Eastern Wheatbelt:—

(a)	10 per cent. Gammexane powder	1 lb.
	Bran	24 lbs.
	Molasses	6 lbs.
	Water	2½ galls.
(b)	10 per cent. Gammexane powder	1 lb.
	Bran	24 lbs.
	Water	2½ galls.

The insects ranged from 1st instar nymphs to fliers but the majority were 3rd and 4th instar hoppers.

The bait was broadcast in the middle of the morning but as a cool wind was blowing the insects did not feed readily until about noon when the conditions were warmer. Both baits were readily taken and within one hour a large number of hoppers were incapacitated. Twenty-four hours after treatment the mortality was very heavy and only a few live insects remained on the treated area. As no attempt was made to isolate the treated plot there is no doubt that many of these live hoppers had migrated on to the area after the laying of the bait. Bait two days' old and apparently quite dry was readily eaten by the hoppers and the sweetened bait appeared to be no more attractive than that lacking molasses.

Plate 4. Cabbages being dusted with D.D.T. by means of a wheelbarrow duster.

Apple Curculio (*Otiorrhynchus cribricollis*).

Tests with 0.15 per cent 666 emulsion were conducted in association with the D.D.T. trals but in both cases results were inconclusive.

Cabbage Moth (*Plutella maculipennis*).

One trial was conducted on a block of cabbages and cauliflowers grown under sprinklers and 1,050 plants were dusted with 2 per cent. "Gammexane" dust at 10-day intervals throughout the growing period.

A crop of cauliflowers grown under swamp conditions was also treated and 400 plants were dusted as in the first trial.

Control of the caterpillars was so poor that the crop was finally treated with D.D.T. to prevent a complete loss to the grower. In contrast to the poor results obtained with "Gammexane" dust good control was obtained on a block of 450 cauliflowers treated at 10-day intervals with 0.2 per cent "Gammexane" emulsion.

Plate 5. Cabbages being dusted with D.D.T. by means of a wheelbarrow duster.

Climbing Cutworm (*Heliothis armigera*).

A block of 180 tomato plants was dusted with 2 per cent. "Gammexane" dust at fortnightly intervals. No serious caterpillar injury occurred, but as the damage on control plants was also very light the test was inconclusive.

Cabbage Butterfly (*Pieris rapæ*).

Results similar to those outlined for the cabbage moth.

SUMMARY.

D.D.T.

D.D.T. did not kill all important insect pests and many mites proved particular resistant. It was very effective against caterpillars and cabbages and cauli-

flowers treated periodically with a 1 per cent. D.D.T. dust were practically free from all signs of chewing injury. Tomato plants treated from seedling to maturity showed a marked reduction in the number of "wormy" fruits.

D.D.T. sprays proved very effective in controlling the buffalo fly, house flies, and stable flies.

Other pests against which D.D.T. gave very satisfactory results were Argentine ant, climbing cutworm, apple leafhopper, vegetable leafhopper and cattle tick.

Indications are that leaf eating orchard pests can be controlled by 0.1 per cent. of D.D.T. sprays but tests against scale insects and many aphids have been disappointing and Bryobia mite appears to be quite unaffected. Much still remains to be learned before D.D.T. can be indiscriminately recommended. Unfortunately it is toxic to mammals as well as to many useful insects such as ladybirds, wasps and bees. Used with discretion, however, its bad effects can be minimised and its beneficial properties exploited.

GAMMEXANE.

"Gammexane" proved inferior to D.D.T. in the present tests against most insect and allied pests. Used in grasshopper baits it proved very much quicker in action than either D.D.T. or arsenite of soda. The superior results obtained from sprays when compared with dusts indicate the need for research into the preparation of mixtures and the methods of application.

"Gammexane" is much less toxic to mammals than D.D.T. or arsenic and consequently has definite advantages over these insecticides for certain purposes.

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Pasture Plants of the Kimberleys.

A Preliminary Report on Their Composition.

L. C. Snook, Animal Nutrition Officer, and K. M. Durack, Research Officer.

MUCH publicity has been given of recent years to the urgent need for developing the northern areas of Western Australia. The Kimberleys, because of the more assured rainfall and the possibilities of irrigation from storage dams built on the Ord River, have received particular emphasis as possible areas of intensive development. The problems of geographic isolation, and of markets for produce, still remain as handicaps to closer settlement but there is reason to hope that the pastoral industry may make considerable advances in the immediate future. And a prosperous pastoral industry may well be the fore-runner of some form of closer settlement.

Since about 1890 cattle have been grazed in the Kimberleys on a very extensive system but the numbers over many years have shown no increase, and the quality of the beef produced, as shown by carcase weight and the percentage reaching export standard, has tended to decline. Of more significance is the fact that pastures carrying cattle have deteriorated, many of the more useful plants and edible shrubs having been replaced by weeds and short lived annuals. The subsequent loss of protective vegetative cover has exposed the soil to the ravages of wind and rain, so that on certain soil types erosion is already a serious problem.

The Kimberley area is essentially pastoral and is likely to remain so for many years. It follows that it is very important to learn everything possible regarding methods by which the natural pastures may be maintained or improved. Under present conditions, feed for cattle is very scarce for months before the rainy season begins, so that the young herbage, when it does appear, tends to be severely overstocked. At a latter stage the feed "gets away" from the stock, and the profuse growth of rank, fibrous grass becomes unsuitable even for cattle. When this mature low-quality herbage becomes dry at the end of the "wet," the grazing animal has to exist for six months or more on very poor quality roughage. There is thus an urgent need for fodder plants which will provide a bulk of feed soon after the first rains, and which will continue to provide green feed for as long as possible after the rains have ceased. During the last twenty or thirty years the changes in the vegetation have tended to reduce the growing period of the Kimberley pastures. These changes must be arrested and reversed. Not only is it urgent to extend the period during which growth takes place but a study must be made of methods whereby the lush mid-season growth may be controlled and conserved. A Research Station has now been established at Ivanhoe on the Ord River, so that these and associated problems may receive attention, thus assisting the pastoral industry to take every advantage of the natural resources of the region.

As a preliminary step in the study of pastoral management it is essential to know something of the composition of the natural herbage. Efforts can then be made to encourage the growth of the more useful plants and to make introductions which are most likely to correct any deficiencies disclosed. To obtain this essential information, a series of samples of grasses grown at Ivanhoe were collected at various stages of growth, and have been analysed to give some index of the relative nutritive value. These analyses are discussed in this paper.

It should be emphasised, however, that many factors affect the chemical composition of plants—season, stage of growth, soil type, management, etc.—and the results recorded here can only be discussed in very general terms. But much of the data are very interesting and give valuable leads for future work.

Experimental.

The various pasture types discussed in this paper were collected from plots in the vicinity of Ivanhoe. In most cases small areas of the naturally growing plants were fenced in so as to be protected from grazing animals, otherwise no treatment at all was given. The areas had been subjected to heavy grazing until towards the end of December, 1944, and this heavy grazing appears to have had a particularly crippling effect on early maturing grasses such as Para. Grasshoppers at times were bad and these doubtless depleted the test plots of some of the more palatable herbage.

Portions of the plots were cut at intervals, the whole of the growth being ground for analyses. This meant that much fibrous matter which normally would not be eaten by stock was included in the material as analysed, hence some of the high figures for crude fibre. A better index of the true feed value would have been obtained had the samples been handpicked to represent that proportion most likely to be eaten by the grazing animal.

The samples were not weighed and no data are available concerning the relative yields from the various plots.

Rainfall.

From July, 1944, until September, 1945, 26.83 inches of rain fell as follows:—

1944.						1945.								
July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
0	0	0	248	46	594	580	702	357	156	0	0	0	0	0

It will be seen that the summer rains are restricted to a definite wet period, no rain being recorded during the dry months. The 1944-45 "wet" was one of subnormal rainfall, the recording for 1943-44 being 39.10 inches and for 1945-46, 34.59 inches.

Soils.

All but two of the grasses examined were obtained from plots on ORD SANDY LOAM, a red alluvial soil laid down by the river. Two plots were situated on CUNUNARRA CLAY, a heavy black soil typical of that found on the extensive Ivanhoe plains.

Analyses.

The analyses were carried out in the Government Chemical Laboratories, standard methods being used in all cases.

Results.

The results have been recorded in detail in the Tables included in this paper. The quality of the various grasses will be discussed in turn.

Buffel and Birdwood Grass (*Cenchrus spp.*) Table I.

Pastoralists will be particularly interested in the analyses of the samples of Buffel and Birdwood grass recorded in Table I. These grasses have attracted considerable attention of recent years as they give promise of becoming very valuable in tropical and subtropical areas. It is therefore pleasing to learn that not only are these grasses hardy and resistant to heavy grazing, but also that they have a high nutritive value.

Buffel Grass was apparently introduced into this State via Port Hedland about 1910, seeds being present in the chaff brought in with camel teams. It is now well established in pastoral country from Carnarvon northward and although for a long while it was looked upon as a "coastal" grass, good stands have been seen up to a hundred miles inland. Stock are very fond of Buffel Grass and overgrazing has doubtless been the main factor in limiting its spread.

Birdwood Grass is similar to Buffel and was introduced from India by General Birdwood, hence its name. It is a pity that there were not distinct plots of these two grasses at Ivanhoe, so that comparisons could be made regarding relative yields and composition. Comparative work will be carried out in due course.

From the details given in Table I it can be seen that these grasses came away well with the first rains, giving "good quality bulky pasture" despite heavy stocking. A very pleasing rapidity of growth took place as soon as the plots were fenced, the sample cut on January 3rd having grown up to three feet high in three weeks. This material had an excellent analysis, containing more crude protein (14 per cent) than most cereal grains. But if left uncut or ungrazed, Buffel grass, like most others in the tropics, quickly matures, becoming rank and fibrous with relatively little digestible protein. This deterioration is shown by the progressive changes in Samples 2, 3 and 4, the sample cut on 20th February containing only one third the total protein present in the sample cut on 3rd January. As plants mature the fibrous material which is formed tends to imprison food constituents, so increasing the difficulty of digestion. This point should always be remembered in comparing the analytical values of young and old herbage.

It is not generally appreciated that young pasture is a rich foodstuff bearing comparison with concentrates for which the pastoralist will pay high prices. To emphasise the value of young pasture of the type obtained from the Buffel and Birdwood grass plots, Table II has been prepared. From this it can be seen that young Buffel grass may contain double the protein present in oat grain grown at Chapman or Wongan Hills, and one and a half times the protein present in F.A.Q. wheat. Not only does this young grass contain a high percentage of good quality protein but it is well balanced in other nutrients for stock.

It is very apparent that Buffel and Birdwood grasses are going to play an important part in the improvement of the Kimberley pastures. They provide good quality early feed and, if correctly managed, this quality can be maintained throughout the growing season. No figures are yet available regarding the weight of feed which is produced by a Buffel and Birdwood pasture in the Kimberleys, but in Northern Queensland test plots of Buffel Grass cut monthly to a height of 2 inches, yielded 3½ tons dry matter per acre per annum, this young material being very nutritious and containing, on an average, 12 per cent. crude protein. The material from similar plots which were cut every three months contained on average only 6 per cent. crude protein, illustrating once again the decline in quality which is seen in grasses as they mature.

Para (*Brachiaria mutica*) Table III.

Para is an introduced grass which has shown considerable promise, particularly as a source of early feed following the first rains. In the wet coastal belt of Northern Queensland Para has proved outstanding as a pasture grass for fattening cattle brought in from the drier areas, and it would be a valuable addition to the Kimberley pastures.

The Kimberley samples of Para were obtained from plots established under sprinkler irrigation in 1943. The plots were not watered in 1944 or 1945. Excellent growth was made with the first rains in November, 1944, Para providing the best feed available on the station. The sample cut for analysis on December, 13th, contained 10 per cent. crude protein compared with the 7 per cent. present in Buffel grass cut at the same time. It is interesting to note that all specimens of Para were rich in phosphate and lime, this plant being the only one of which all samples contained adequate amounts of these essential elements.

Six cuts of the grass on this plot were made between December 13th, and April 9th. It is probable that the frequent cutting was harmful to the plants and was partly responsible for their progressive decline. Sufficient time must elapse between cuttings so that the leaves can supply adequate nutrients to the roots to maintain the plant in full vigour. Para is a stemmy grass and it is said that cattle eat only the succulent leaves. It is evident from the high crude fibre content of the samples collected towards the end of the season at Ivanhoe, that much stemmy matter was included. This was unfair to the plant because it lowered the apparent feeding value, and the loss of the stem reduced the ability of the plant to recover from the cuttings.

Lack of nitrates in the soil was probably the important factor in the progressive decline of the Para grass, as shown in Table III. Rapidly growing grasses need generous supplies of nitrogenous constituents if productivity is to be maintained, especially in tropical regions where nutrients are often so readily leached from the soils by heavy rain. The most satisfactory way to supply pasture grasses with nitrates is to grow legumes in association with them. It is therefore very interesting to learn that, where Para has been grown in association with lucerne, a vigorous growth of healthy deep-green nutritious grass has been obtained, in contrast to the unthrifty pale-green herbage from Para growing in a pure stand. The analytical figures recorded in Table IV are very significant and indicate the great benefit which would result if a self-regenerating legume could be found which could be incorporated in the grass pastures of the tropics. As can be seen, Para grass growing with lucerne provided twice the amount of protein and a much heavier yield of more nutritious fodder.

Wherever irrigation is practicable it seems that Para and lucerne will form an excellent combination and much is anticipated from the success of this and similar mixtures. Once Para and lucerne plants have become established they may persist in the Kimberleys without irrigation and, with the early rains, would provide a considerable bulk of excellent fodder.

As an index of the carrying capacity of Para under good conditions, results obtained in the wet coastal belt of Northern Queensland may be quoted. Here a test area of 240 acres supported 100 head of cattle throughout the year. Four paddocks, each 60 acres, were grazed in turn for a period of three weeks. The quality of the pasture under this system of rotational grazing remained excellent, the protein ranging between 12 and 15 per cent. It is important to learn just what use can be made of Para in the Kimberleys.

Kangaroo Grass (*Themeda triandra*) Table V.

Kangaroo grass may be taken as typical of the indigenous perennial grasses which develop rapidly with the first rains, providing fair feed while young, but quickly becoming so rank and coarse as to be practically useless even for cattle. The analytical figures in Table V illustrate very well the quick maturity and rapid deterioration characteristic of these grasses.

The plots from which the samples were obtained were heavily grazed in December, the Kangaroo grass providing a good bulk of early feed. The area was never enclosed but the plants grew vigorously so that in a matter of weeks the grass was too coarse for use as stock feed.

For purposes of comparison, the analytical values of Kangaroo grasses grown in various part of South Africa are appended to Table V. The same poor quality herbage is evident, so it seems that kangaroo grass is naturally of low nutritive value. The low phophate and calcium content of the Kimberley samples suggests this possibility also, as they were grown on the same soil type as the Para, which was so rich in minerals. It seems that better grasses than Kangaroo grass should be encouraged.

Flinders Grass (*Iseilema fragile*) Table VI.

This grass may be taken as an example of the quick growing annuals which are considered quite good grasses by the pastoralist, but which have the disadvantage of a comparatively short period during which they provide feed. As can be seen from the Table, the Flinders grass does not respond to the first rains as quickly as do perennials which already have a robust root stock awaiting the opportunity to develop. Admittedly the presence of grazing animals may have retarded the growth of young seedlings in December but it was not until mid January that the Flinders grass began to make headway. By the end of March the grass had seeded and become almost useless as a feed, which indicates a very short period of effective growth. As far as one can judge from the figures in Table VI, Flinders grass has little to recommend it and the data support the contention that perennials are essential if reasonable pastures are to be maintained in the Kimberley areas. It is probable that the decline in carrying capacity and the onset of erosion is in most cases associated with the replacement of the native perennials by annuals.

Sehima (*Sehima nervosum*) Table VII.

On portions of the black soils typical of the Ivanhoe plains, Sehima has become the dominant pasture grass, having replaced more useful perennials which have been less able to withstand stocking. Sehima does not make a great deal of growth during the early part of the season. It seems to conserve and consolidate its resources until feed is plentiful so that it does not suffer from overgrazing by hungry stock in December and January. This protective inactivity is said to be the main reason for the dominance of Sehima in the pastures today. During February and March the plants make rapid growth and quickly reach maturity. As far as one can judge from Table VII, Sehima herbage is of little value at any stage of growth, being very fibrous and a poor source of protein and minerals.

Because it is the major plant constituent of the pastures over extensive areas it may be necessary to work out methods of management which will utilise Sehima to the best advantage but apparently there are other perennials of much better quality which should be introduced as soon as is practicable.

Sugar Grass or Native Sorghum (*Sorghum plumosum*) Table VIII.

The native sorghums are robust annuals which provide some early feed and then make such vigorous growth that the tall canes soon become useless to stock, except for short watery shoots which grow from the nodes. As far as one can judge, this plant as a fodder grass has little to recommend it—it provides significant quantities of food for only a short period of the rainy season, and the nutritive value of the samples collected were very low. It seems unlikely that native sorghums will withstand repeated cutting and it is obvious that the plants are of little value if left to mature. Perhaps some system of management may be devised which can turn to advantage the vigor of this bulky plant but meanwhile the pastoralist seems advised to make maximum use of more easily utilised species.

Nigger-head (*Enneapogan polyphyllus*) Table IX.

Nigger-head is considered quite a useful grass by pastoralists, as it supplies green feed over an extended period and it is useful in the reclaimation of scoured ground. As can be seen from Table IX Nigger-head provided feed of a reasonable quality over a much longer period than many other natural grasses. The high figures for crude fibre suggest that considerable inedible material was included in the samples cut for analysis. This being so, one could assume that cattle would obtain herbage of considerably higher nutritive value by selective grazing.

It seems that Nigger-head is one of the useful grasses well worth further study, especially as it may play an important role in the building up of depleted soils.

Native Couch (*Brachyachne convergens*) Table X.

Native couch provides good feed over a short period but it is another of the short term annuals which should be replaced by perennials. This grass provides no cover for the soil during the dry months, and ground so exposed may become "scalded." The samples of native couch analysed were remarkably deficient in minerals.

Bunch Spear Grass (*Heteropogon contortus*) Table XI.

Because of its savage seed-head this grass, when mature, is disliked by man and beast. While young, however, it provides quite useful early feed following the first rains, and heavy stocking during this period should give some measure of control of a grass which has nothing else to recommend it.

GENERAL DISCUSSION.

Protein.

As can be seen from the various Tables in this paper, the herbage available to stock in the Kimberleys during the long dry winter, is very deficient in protein. The mature herbage from even the best grasses contains only about 4-5 per cent. crude protein while the poorer species may contain no more than 1-2 per cent. for many months of the year. Not only is the dry herbage very deficient in total protein but this protein is of little use to the grazing animal because of its low digestibility. In young grass, such as the sample of Buffel-Birdwood grass containing 16 per cent. protein, about 80 per cent. of this protein can be used by the animal. When the plant matures and the protein drops to about 6 per cent. it is doubtful if half of this can be used by the animal: if the protein drops to 3 per cent. or less it is considered that none is of any use (White, 1940).

The grazing animal, by selecting seeds, seedheads, young shoots and topfeed, probably obtains a diet richer in protein than the figures in the Tables would imply, but even so, months of selective grazing and continued weathering must reduce the quality of the pasture to a very low status in the months preceding the summer rains.

Possible methods by which the protein intake of Kimberley cattle may be raised are:—

1. Introduction of a pastoral legume.
2. Cutting natural herbage when it contains adequate protein and conserving it for use during the months of scarcity.
3. Establishing perennials which prolong the period during which nutritious feed is available.

Introducing a legume:

Most countries with tropical or subtropical pastoral areas have been seeking a legume which will do for them what sub-clover has done for southern Australia, but to-date the search has been unavailing. Plants which have shown promise elsewhere are even now being tried in the Kimberleys but success has still to be proved. Lucerne does very well but as it is essentially a cultivated plant it cannot be used for the improvement of extensive natural pastures. There is every hope, however, that lucerne will play a very important role as a component of irrigated pastures and in due course lucerne hay may be available in considerable quantities. But a pastoral legume which will become widespread in the natural pastures of the tropics has yet to be found.

Cutting Natural Herbage.

The control of pastures by periodic intensive grazing and/or mowing has resulted in marked increases in carrying capacity wherever it has been adopted. Even when the herbage has been cut only once or twice during the growing season, the results have often been spectacular. As an illustration of the value of haymaking in pastoral country, the results obtained in Queensland on Mitchell grass country can be quoted (Davies et. al. 1938). The natural pasture normally carried one sheep to four acres but it was found that the hay cut in one month (April) provided sufficient food to support the equivalent of two sheep per acre all the year. Results such as these show that when grass is allowed to mature, the bulk of the herbage is in fact wasted.

It would be very interesting to determine the value of the hay obtainable by repeated cutting of selected Kimberley pastures during the growing season. Much would depend on the response of the native species; some would doubtless lose their vigour but if they were in due course replaced by better types such as Buffel or Birdwood grass, so much the better.

It is hoped that some form of pick-up baler will be adapted for use in harvesting hay in the northern areas. The economic use of such labour-saving machinery might do much to revolutionise live-stock husbandry in the Kimberleys, and the practical problems associated with such developments warrant immediate attention.

Establishing Perennials.

The efficient use of permanent perennial pastures requires the development of some system of rotational grazing and/or cutting of the herbage, which in turn requires the outlay of considerable capital in fencing, machinery and water-

supplies. It is possible that such a system may be gradually built up to perfection, first by the use of machinery to cut the excess growth on the natural pastures, then by the gradual introduction of better quality plant species, and eventually by the use of small paddocks (with or without irrigation) which can be subjected to intensive rotational grazing. Just how all this can be achieved has yet to be determined but only by some such system of progressive agriculture can the Kimberleys be expected to support a prosperous rural community of any permanence.

MINERAL CONSTITUENTS.

Phosphorus.

When Sir Arnold Theiler, who did so much of the pioneer work which showed the importance of phosphatic supplements to South African veld cattle, visited this State he reported that the Kimberley cattle he saw showed characteristic symptoms of phosphorus deficiency. As these cattle are required to subsist for six months or more on mature grass which is characteristically deficient in phosphorus, it was then accepted that lack of this essential element was probably a major factor limiting the well-being of stock in these areas. Of recent years the emphasis has shifted from phosphorus deficiency to the lack of other constituents such as protein, but it is well to remember that phosphorus continues to be a prime necessity to growing and lactating animals.

As a basis for discussion it can be taken that a pasture should provide at least 0.20 per cent. P in the part that is eaten by the animal. Very few of the samples discussed in this paper supply this desired minimum and it is important to consider possible causes and effects.

A pasture may be lacking in phosphate because the soil on which it is growing is deficient, or because the plants of which it is composed do not normally assimilate a great deal of phosphorus, or because the samples are collected at a stage of growth when the plants have a minimum phosphorus content.

In large areas of Western Australia the soils are notoriously deficient in useful phosphates and such data as are available suggest that the Kimberley soils are also lacking in this element. To date, however, dressings of superphosphate have not given any appreciable increases in yields and it seems that other deficiencies are equally important limiting factors. Plant species such as Buffel, Birdwood, and Para grasses were able to obtain adequate supplies of phosphate; this suggests that the low percentage found in other species is a natural characteristic. This brings one to the second possibility, namely, that grasses such as Kangaroo, Flinders and Sehima, do not absorb a great deal of phosphorus and are therefore poor sources of the element for the grazing animal. If such is the case, this supplies yet another reason for improving the pasture by concentrating on the more desirable species.

The phosphate content of a pasture varies considerably with the age of the component plants. Young Buffel grass may contain 0.3 per cent. P in the dry matter, whereas the mature plant may contain only 0.06 per cent. Unfortunately many of the plants grown at Ivanhoe were deficient in phosphorus at *all* stages of growth, particularly so when mature. Thus Flinders grass in flower contained only 0.11 per cent P and Sehima just coming into flower contained only 0.08 per cent. Contrast these low figures with the 0.25 per cent P present in Buffel grass at the pre-flowering stage, or with Para which showed a maximum value of 0.45 per cent. and a minimum of 0.26 per cent P.

The presence of a certain proportion of edible plants having a high phosphate content can do much to redeem the deficiencies of the bulk of the herbage. Shrubs and various types of "topfeed" are characteristically rich in phosphorus and where stock have access to these, no evidence of deficiency may be apparent even after long periods on otherwise dry pasture. Legumes are rich in phosphorus, as also are most seeds. Again, certain classes of stock, particularly sheep, can persist for a long period on rations low in phosphorus, so long as the pasture during the "flush" is rich in this element. Cattle, however, are more sensitive to lack of phosphate in the diet, especially if pregnant or lactating. It so happens that the Kimberley breeding cows carry their calves during the major portion of the dry months and phosphorus deficiency must be a factor accentuating the general undernourishment. For this reason it seems important in the Kimberleys to encourage the growth of plants rich in phosphorus and, if possible, to conserve herbage cut when the phosphorus content is at a peak. Fortunately it so happens that any steps taken to increase the protein content of the herbage will also lead to an increase in available phosphorus.

Calcium.

Western Australian pastures generally contain adequate calcium or lime for the needs of grazing animals. Some of the Kimberley samples, particularly the native sorghums, were somewhat deficient in this essential element but it seems very unlikely that stock on mixed pasture would be handicapped in any way by a lack of lime. The growth rate and milk flow of Kimberley cattle is most likely to be limited by lack of protein and phosphorus, and even by lack of energy-producing food during the latter part of the dry season.

Minor Elements.

All stock breeders are now familiar with the important role played by the so-called "trace" elements. The use of comparatively small amounts of copper, for example, has eliminated serious and costly stock ailments over large areas of country in Western Australia alone. If the Kimberleys are to be developed on anything like an extensive scale it is therefore important to anticipate, if possible, the likelihood of trace element deficiencies in the pastures.

Samples of the various grasses collected at Ivanhoe about flowering time, were therefore analysed to show the copper, cobalt, zinc and manganese contents, these minerals being among those now known to be of importance in nutrition. The results are recorded in Table XII. The figures for a "standard" good quality pasture have been appended to the foot of the Table for comparative purposes.

The amounts of the essential elements present in the various samples vary considerably. Further samples will need to be analysed to confirm the marked variation seen between the species but it is satisfactory to note that the "good" quality grasses such as Buffel, Birdwood and Para, supply adequate amounts of the trace elements under consideration. The less desirable grasses such as Kangaroo, Sehima and Bunch Spear grass are in most cases seriously deficient in essential elements but it seems that so long as the animals can graze on mixed pastures, there is no obvious danger of trace element deficiencies affecting the well-being of the stock. For example, the native sorghums are rich in Zn but very deficient in Co, whereas native couch is just the reverse. Either grass alone would not suffice but together the mixture would supply ample of the two elements mentioned. The value of a varied diet has always been stressed by good husbandrymen and this simple example illustrates very well the virtues of a mixed pasture. As far as one can judge from Table XII it seems that alluvial "Ord sandy loam"

will grow good quality pasture free from obvious trace element deficiencies but we should remember that other soil types in the Kimberleys may not be so productive of 'complete' pastures. In fact, the low values for copper and cobalt seen in some of the indigenous species of pasture plant, arouse the suspicion that deficient areas may occur. Further studies may prove very interesting, if only to achieve an explanation for the surprising low copper and cobalt values found in some of the native plants.

Vitamin A.

No Vitamin A determinations were made on any of the Kimberley pastoral samples but dry natural pastures are characteristically deficient in this essential nutrient. Lack of this vitamin can cause sterility in sheep and cattle before there is any evidence that the general health is affected. In the Kimberleys cattle will not mate until a month or so following the growth of green feed. This means that the calves are dropped towards the end of the following dry period, which places maximum strain on the pregnant cow and jeopardises the survival of the calf. Supplies of meadow hay, cured so as to give maximum conservation of Vitamin A, would do much to minimise the evils of this system, firstly by supplying nutrients about the time of calving, and secondly, by giving the pastoralist a means to induce mating by supplementary feeding and so possibly to change the calving date to a more favoured time of the year.

SUMMARY.

Serial samples of grasses growing under natural conditions at Ivanhoe Station on the Ord River in the Kimberleys, North West Australia, were collected during the growing season and analysed to show the crude protein, crude fibre, phosphate and calcium content.

A sample of each species, collected about the flowering stage, was further analysed to show the copper, cobalt, zinc and manganese content.

The quality of the herbage varied considerably between species, and within the species according to the stage of growth.

The best fodder was obtained from a mixture of Buffel and Birdwood grasses, which supplied a considerable bulk of nutritious herbage throughout the wet season. When kept young by rotational grazing or cutting, the Buffel-Birdwood mixture produced herbage with 14-16 per cent. crude protein in the dry matter, and adequate supplies of all the minerals examined.

In contrast, native perennials (Kangaroo Grass, Schima) and native annuals (Flinders grass, native sorghum) supplied useful fodder over only a short period, the food value of this fodder was never very high, and the mature growth was mostly useless as a stockfeed.

Under the present system livestock must subsist for most of the dry period on a diet deficient in protein, as the best quality dry grasses contain only 3-5 per cent. crude protein in the dry matter and the bulk of the dry herbage contains as little as 1-3 per cent.

Some of the native perennials are deficient in minerals but the better quality plants apparently supply adequate amounts of all the essentials examined, at least during the growing period.

On the evidence available it seems that the obvious deficiencies occurring in the Kimberley pastures may be corrected by the extended use of the better quality plants, and the introduction of methods of controlled grazing and fodder conservation.

An investigation of methods of cutting and conserving green pasture for use during the long dry period is urgently needed.

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TABLE I.

MIXTURE :—*Buffel and Birdwood Grass (Cenchrus ciliaris and C. setigerus).*
Grown on Ord Sandy Loam (Red alluvial).

Percentage composition on dry weight basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25.	Crude Fibre.	Phosphorus P.	Calcium Ca.
			%	%	%	%
1	13-12-44	Good quality bulky pasture, mostly young growth following heavy grazing	7·1	31	·12	·40
2	3-1-45	From area burnt on 13th December. 1½–3ft. high, advanced flowering	14·3	27	·18	·38
3	22-1-45	Mature seed stage	9·4	33	·16	·27
4	20-2-45	Very mature. Much seed has fallen	5·5	36	·14	·21
5	7-3-45	Pre-flowering stage. From area grazed once and mown once	15·7	28	·29	·36
6	23-3-45	Mature grass (not cut when sample No. 5 was collected)	8·1	36	·25	·30
7	9-4-45	Sample represent two weeks growth after removal of stock	16·0	26	·21	·28
8	25-4-45	As for No. 7, one month after removal of stock	13·9	31	·32	·27
9	13-5-45	Mature grass not wholly dry. Seed fallen	3·6	32	·10	·34
10	5-7-45	Dry mature grass. Seed fallen	4·7	33	·06	·31
11	5-8-45	Dry mature grass. Seed fallen	5·3	32	·07	·33
12	1-10-45	Dry mature grass. Seed fallen	5·9	34	·09	·30

TABLE II.

Value of Young Pasture.

Comparative Figures.

Percentage Composition on Dry Weight Basis

Foodstuff.	Crude Protein. N × 6·25	Crude Fibre.	Phospherous as P	Calcium as Ca.
	%	%	%	%
Buffel and Birdwood Grass cut 7th March, in pre-flowering stage	16	28	·29	·36
Oaten Hay—average of 36 samples grown at Merredin, W.A.	5	28	·12	·06
W. Aust. F.A.Q. wheat grain. Average of 7 years	11	3	·24	·04
Oat grain grown at Wongan Hills. Average of 5 years	8·5	12	·20	·06
Oat grain grown at Chapman. Average of 5 years	8·5	12	·27	·07
Young subterranean clover grown at Harvey, W.A. Cut 22nd August	21	20	·30	·84

TABLE III.

Para (Brachiaria mutica Forsk) Stapl.

Grown on Ord Sandy Loam (Red Alluvial).

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25	Crude Fibre.	Phosphorus P	Calcium Ca.
			%	%	%	%
1	13–12–44	Growth made in week following rains. (This grass providing best feed available at time of cutting)	9·5	30	·26	·69
2	3–1–45	Regrowth following cutting of sample 1	8·8	31	·43	·54
3	22–1–45	Regrowth following cutting of sample 2	6·8	32	·44	·46
4	20–2–45	Regrowth following cutting of sample 3	5·2	36	·30	·46
5	7–3–45	Regrowth following cutting of sample 4. Grass beginning to show lack of vigour	5·2	35	·45	·35
6	23–3–45	Regrowth following cutting of sample 5	5·1	49	·27	·41
7	9–4–45	Regrowth following cutting of sample 6	5·1	52	·26	·47
8	25–4–45	No sample taken as growth very poor	...	...	...	...

General.—This plot of grass was established by sprinkler irrigation early in 1943. Was not watered in 1944 or 1945.

TABLE IV.

Para Grown Alone and with Lucerne. Irrigated.

Para Grass.	Age of Plants	Colour of Leaves	Composition as percentage of dry matter.				Relative Yield.
			Crude Protein N x 6·25	Crude Fibre.	Ca	P	
A. grown with lucerne	6 months	Deep green	12·5	31	·27	·29	10
B. grown alone	6 months	Pale green	6·2	32	·18	·30	6
C. grown alone	25 months	Very pale green	3·6	33	·30	·29	2

A. and B. cut monthly. Sample regrowth of one month. C. grazed until three months before sampling.

TABLE V.

Kangaroo Grass (Themeda triandra) Forsk.

Grown on Ord Sandy Loam.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25.	Crude Fibre.	Phosphorus P.	Calcium Ca.
			%	%	%	%
1	19–1–45	Vigorous growth following removal of stock on December 30. Plants in pre-flowering stage and already too coarse for stock	5·8	36	·18	·30
2	18–2–45	5 ft. high. In flower	3·4	42	·11	·21
3	15–3–45	Past flowering stage	4·2	39	·12	·26
4	30–3–45	Mature grass still green	3·2	38	·12	·28
5	13–4–45	Mature grass drying off	2·6	38	·11	·30
6	12–5–45	Fairly dry	2·6	37	·13	·31
7	5–7–45	Quite dry	1·4	40	·12	·32
8	5–8–45	Quite dry	1·0	41	·09	·29
9	3–10–45	Quite dry	1·2	41	·12	·22
		Average	2·9	...	·07	·23
		Range	2·0–5·0	...	·04–·13	·17–·32

13 samples of Kangaroo Grass, green but mainly mature, collected in Union of South Africa, 1931.

TABLE VI.

Flinders Grass (Iseilema fragile) S. T. Blake.

Grown on Cununurra Clay (heavy black soil).

Percentage composition on Dry Matter Basis.

Sample No.	Collected.	Nature of Sample.	Crude Protein N x 6·25	Crude Fibre.	Phosphorus P	Calcium Ca.
			%	%	%	%
1	1–1–45	No sign of this grass—plot had been grazed	...	...	...	...
2	19–1–45	Grass showing, following enclosure	...	...	...	...
3	18–2–45	Grass in flower—about 2ft. high	4·5	38	·11	·25
4	15–3–45	Just past flowering stage	2·5	38	·10	·24
5	30–3–45	Mature—drying off	2·3	38	·10	·26
6	13–4–45	Amost dry	2·3	38	·10	·24
7	12–5–45	Quite dry	2·0	38	·09	·20
8	5–7–45	Quite dry	1·5	37	·07	·22
9	5–8–45	Quite dry	1·3	36	·08	·17
10	5–8–45	Quite dry	3·0	36	·08	·17
11	3–10–45	Quite dry—sheaf prepared of grass 18–24ins. high. Seed had fallen ...	1·6	39	·09	·23

TABLE VII.

Sehima (Sehima nervosum) (Roth.) Stapf.

Grown on Cunnunurra Clay.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample. Sehima is the dominant grass in the Ivanhoe black soil pastures.	Crude Protein N x 6·25.	Crude Fibre.	Phosphorus P.	Calcium Ca.
			%	%	%	%
1	13–12–44	No evidence of growth	...	...	...	...
2	17–12–44	Fair shoot among old stools	...	...	...	...
3	1–1–45	Good releif feed among old stools	...	...	...	...
4	19–1–45	Area enclosed on 1st January, and adjacent ares, not worth sampling ...	...	...	...	...
5	22–2–45	3ft. 6in. high and just coming into flower	4·6	40	·08	·46
6	9–3–45	Up to 5ft. high. In flower	4·1	42	·06	·34
7	23–3–45	Mature grass quite green	4·1	39	·06	·40
8	9–4–45	Mature grass —still green	3·4	40	·05	·43
9	25–4–45	Mature grass. Seed fallen from first heads but fresh heads forming ...	3·1	40	·06	·37
10	5–7–45	Quite dry	1·7	39	·03	·42
11	5–8–45	Quite dry	1·1	34	·02	·38
12	1–10–45	Quite dry. White lower leaves selected	1·4	37	·02	·45

TABLE VIII.

Sugar Grass or Native Sorghum (S.plumosum (R.Bo.) Beauv.).

Grown on Ord Sandy Loam.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25.	Crude Fibre.	Phosphorus P.	Calcium Ca.
			%	%	%	%
1	13–12–44	Germinated with first rains but eaten out by stock and grasshoppers ...	...	...	...	...
2	1–1–45	Stock still keeping pasture very low	...	...	...	...
3	19–1 45	Remarkable growth following rains and removal of stock three weeks previously	4·2	32	·26	·39
4	18–2–45	Grass up to 6ft. high. Not in flower	4·2	40	·15	·24
5	15–3–45	Over 8ft. high and fully in flower	4·2	32	·23	·17
6	30–3–45	Drying off	2·3	43	·15	·13
7	13–4–45	Half dry	2·3	43	·15	·13
8	12–5–45	Almost dry	1·3	42	·16	·12
9	5–7–45	Quite dry—very little flag	0·9	46	·17	·12
10	5–8–45	Quite dry—no flag	0·9	46	·18	·10

TABLE IX.

Nigger Head (Enneapogan polyphyllus) (Domin), N. T. Burbidge.

Grown on Ord Sandy Loam.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25.	Crude Fibre.	Phosphorus P.	Calcium Ca.
			%	%	%	%
1	13–12–44	Sample not taken. Growth sparse among dense mass of old stems. Area burnt	...	...	...	...
2	3–1–45	Sample taken from unburnt area as burning killed old plants	10·8	38	·23	·71
3	22–1–45	Sample taken adjacent to 2. Flowering	9·1	39	·18	·59
4	20–2–45	Mature grass starting to dry off. Seed falling	6·7	41	·12	·48
5	7–3–45	Sample from seedlings growing on burnt area. Seems poorer species of grass	4·6	41	·22	·30
6	23–3–45	Same type as 5. Mature grass drying off	7·8	41	·12	·26
7	9–4–45	Regrowth from area 2, 3 and 4. Well in flower	4·4	40	·18	·46
8	25–4–45	From area 7. Still quite green and in good condition	6·8	48	·11	·56
9	13–5–45	From area 7. Still green and in good condition	2·9	39	·14	·44
10	5–7–45	From area 7. Still fairly green and in good condition	3·1	38	·15	·67
11	5–8–45	From area 7. Not wholly dry	4·3	39	·15	·61
12	1–10–45	Dry, seed dropped. Leafy type about 1ft. tall	2·9	38	·15	·41
13	1–10–45	Dry, seed dropped. Erect and non-leafy type	2·4	35	·08	·27

TABLE X.

Native Couch (Brachyachne convergens (F. Muell.) Stapf.

Grown on Ord Sandy Loam.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25	Crude Fibre.	Phosphorus P	Calcium Ca.
			%	%	%	%
	13–12–44	No germination apparent	...	...	...	...
	17–12–44	Heavy germination. Providing feed but not sampled	...	...	...	...
1	19–1–45	Well in flower. Plants made remarkable growth in three weeks following removal of stock	12·9	33	·25	·46
2	18–2–45	Grass drying off. Much seed has fallen	5·4	34	·08	·31
3	15–3–45	Grass in good condition with much fresh growth	8·1	36	·10	·32
4	30–3–45	Grass drying	4·9	36	·08	·29
5	13–4–45	Almost dry	5·6	36	·07	·31
6	13–5–45	Dry grass	4·8	35	·07	·36
7	5–7–45	Dry grass from protected enclosure	3·5	33	·21	·35
8	5–8–45	Dry grass	3·5	33	·20	·35
9	1–10–45	Dry plants about 1 ft. high; seed largely fallen	7·9	43	·03	·47

TABLE XI.

Bunch Spear Grass (Heteropogon contortus) (L.) Beauv. ex R. & S.

Grown on Ord Sandy Loam.

Percentage Composition on Dry Matter Basis.

Sample No.	Date Collected.	Nature of Sample.	Crude Protein N x 6·25	Crude Fibre.	Phosphorus P	Calcium Ca.
...	...	This grass produced much very early feed of great value and area was heavily stocked until 5th January	% ...	% ...	% ...	% ...
1	19–1–45	Grass progressed well after removal of stock	7·6	36	·13	·23
2	18–2–45	Up to 4ft. 6in. high ; coming into flower	3·2	42	·07	·16
3	15–3–45	Up to 4ft. 6in. high ; in flower. Seed not formed	3·0	42	·07	·11
4	30–3–45	Mature grass but quite green	2·7	42	·07	·14
5	13–4–45	Mature but green	3·1	38	·08	·18
6	12–5–45	Fairly dry. Seed fallen	1·9	38	·11	·25
7	5–7–45	Almost dry	1·4	41	·06	·22
8	5–8–45	Fairly green sample	1·1	37	·07	·36
9	3–10–45	Mostly dry. Seeds dropped	0·9	37	·05	·34

TABLE XII.

Minor Elements in Pasture Samples, Ivanhoe Area, Kimberleys.

Date Collected.	Species.	Composition—percentage dry matter							Parts per million in dry matter.				Soil Type.
		Nitrogen N.	Crude Protein. N x 6·25	Crude Fibre.	Phosphorus P.	Calcium Ca.	Potassium. K	Magnesium. Mg.	Copper Cu.	Manganese. Mn.	Zinc Zn.	Cobalt Co.	
3–1–45	Buffel and Birdwood grass	2·29	14·3	27	·18	·38	3·31	·26	9·8	64	46	·20	Ord sandy loam.
13–12–44	Para	1·52	9·5	30	·26	·69	2·42	·38	11·9	112	80	·56	Ord sandy loam.
18–2–45	Kangaroo grass...	·54	3·4	42	·11	·21	·83	·10	3·2	56	27	·03	Ord sand loam.
18–2–45	Flinders grass ...	·72	4·5	38	·11	·25	1·67	·23	3·7	44	51	·14	Cunnunurra Clay.
9–3–45	Sehima	·65	4·2	42	·06	·34	·78	·11	2·9	18	32	·09	Cunnunurra Clay.
15–3–45	Native Sorghum	·67	4·2	32	·23	·17	1·22	·18	4·5	34	81	·03	Ord sandy loam.
22–1–45	Nigger-head ...	1·46	9·1	39	·18	·59	1·53	·21	7·3	45	19	·21	Ord sandy loam.
19–1–45	Native Couch ...	2·07	13·0	33	·25	·46	2·25	·33	7·1	86	21	·13	Ord sandy loam.
15–3–45	Bunch Spear Grass	48	3·0	42	·07	·11	·92	·14	3·0	74	31	·07	Ord sandy loam.
For Comparison	Good quality Mixed pasture	2·56	16·0	23	·3	·7	2·5	...	9	50	40	·12	

Fertilisers.

The following fertilisers have been registered at the Department of Agriculture under the Fertiliser Act, 1928, for the year commencing 1st November, 1946:—

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Works† or Perth.‡
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
A.—MINERAL.				%	%	%	%	%	%	%	%	%	%	£ s. d.
1.—NITROGENOUS.														
(a) *Nitrogen as Nitrate*—														
Nitrate of Soda	11	Cresco	Cresco Fertilisers, Ltd.	15·50	....	....	....	....	....	....	....	....	....	18 10 0†
	18	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	15·50	....	....	....	....	....	....	....	....	....	18 10 0†
	30	ML in diamond....	do. do.	15·50	....	....	....	....	....	....	....	....	....	18 10 0†
	37	Sickle	do. do.	15·50	....	....	....	....	....	....	....	....	....	18 10 0†
	51	Faulding's	F. H. Faulding & Co.	16·00	....	....	....	....	....	....	....	....	....	37/4 per cwt. ‡
	55	Champion	R. Dundas Smith & Son	16·00	....	....	....	....	....	....	....	....	....	*
(b) *Nitrogen as Ammonia*—														
Sulphate of Ammonia	12	Cresco	Cresco Fertilisers, Ltd.	....	20·50	....	....	....	....	....	....	....	....	18 10 0†
	45	Elephant....	Cuming Smith & Mt. Lyell F.F., Ltd.	....	20·50	....	....	....	....	....	....	....	....	18 10 0†
	52	Faulding's	F. H. Faulding & Co.	....	20·00	....	....	....	....	....	....	....	....	32/8 per cwt.‡
	53	do.	do. do.	30·00	....	....	....	....	....	....	....	....	....	65/4 per cwt.‡
2.—PHOSPHATIC.														
(a) *Rock Phosphate*—														
Phosphate Powder	15	Cresco	Cresco Fertilisers, Ltd.	....	....	....	....	....	....	....	27·50	....	....	7 8 6†
(b) *Superphosphate*	5	Cresco	Cresco Fertilisers, Ltd.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	5 3 6†
	6	do.	do. do.	....	....	....	....	15·00	2·50	1·50	19·00	....	....	5 8 6†
	19	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	15·00	2·50	1·50	19·00	....	....	5 8 6†
	31	ML in diamond....	do. do.	....	....	....	....	15·00	2·50	1·50	19·00	....	....	5 8 6†
	38	Sickle	do. do.	....	....	....	....	15·00	2·50	1·50	19·00	....	....	5 8 6†
(c) *Rock Phosphate and Superphosphate*—														
50/50 Phosphate	16	Cresco	Cresco Fertilisers, Ltd.	....	....	....	....	7·00	1·50	13·50	22·00	....	....	6 16 0†
3.—POTASSIC.														
(a) Sulphate of Potash	13	Cresco	Cresco Fertilisers, Ltd.	....	....	....	....	....	....	....	....	30·00	....	16 13 0†
	20	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	....	....	30·00	....	16 13 0†
	65	Chandler	State (W.A.) Alunite Industry	....	....	....	....	....	....	....	....	30·00	....	8/10·7 per unit.†
(b) *Muriate of Potash*	14	Cresco	Cresco Fertilisers, Ltd.	....	....	....	....	....	....	....	....	60·0	....	29 17 5†
	21	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	....	....	60·00	....	29 17 5†

FERTILISERS.—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O)		Cash Price per ton on rails† at Works‡ or Perth.
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
(*b*) *Muriate of Potash*	32	ML in diamond....	Cuming Smith & Mt. Lyell F. F., Ltd.	....	....	....	....	....	....	....	...	60·00	..	29 17 5†
	39	Sickle	do. do.	....	....	....	....	....	....	....	....	60·00	....	29 17 5†
4.—NITROGEN AND PHOSPHORIC ACID														
Potato Manure "C"	9	Cresco	Cresco Fertilisers, Ltd.	....	3·50	....	...	11·75	2·00	1·50	15·25	....	....	8 9 10†
Do. "C"	22	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	3·50	....	....	11·75	2·00	1·50	15·25	....	....	8 9 10†
Do. No. 2	33	ML in diamond....	do. do.	....	3·50	....	....	11·75	2·00	1·50	15·25	....	....	8 9 10†
Do. "C"	40	Sickle	do. do.	....	3·50	....	....	11·75	2·00	1·50	15·25	....	....	8 9 10†
5.—NITROGEN PHOSPHORIC ACID AND POTASH.														
Potato Manure "A"	8	Cresco	Cresco Fertilisers, Ltd.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 16 11†
Do. "A"	23	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 16 11†
Do. "B"	24	do.	do. do.	....	3·50	....	....	9·50	1·50	1·25	12·25	5·00	....	10 9 3†
Do. "A"	34	ML in diamond....	do. do.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 16 11†
Do. No. 3	35	do.	do. do.	....	3·50	....	....	9·50	1·50	1·25	12·25	5·00	....	10 9 3†
Do. "A"	41	Sickle	do. do.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 16 11†
Do. "B"	42	do.	do. do.	....	3·50	....	....	9·50	1·50	1·25	12·25	5·00	....	10 9 3†
Do. "B"	57	Cresco	Cresco Fertilisers. Ltd.	....	3·50	....	....	9·50	1·50	1·25	12·25	5·00	....	10 9 3†
Orchard Manure	10	do.	do. do.	5·00	....	....	....	7·50	1·25	·75	9·50	9·80		14 9 9†
Do.	27	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	5·00	....	....	....	7·50	1·25	·75	9·50	....	9·80	14 9 9†
Do.	36	ML in diamond....	do. do.	5·00	....	....	....	7·50	1·25	·75	9·50	....	9·80	14 9 9†
Do.	43	Sickle	do. do.	5·00	....	....	....	7·50	1·25	·75	9·50	....	9·80	14 9 9†
Do. No. 2	59	ML in diamond	do. do.	5·00	....	....	....	7·00	1·25	·75	9·00	5·00	....	12 5 8†
Do. No. 2	60	C.S.M.L.	do. do.	5·00	....	....	....	7·00	1·25	·75	....	5·00	....	12 5 8†
Do. No. 2	61	Sickle	do. do.	5·00	....	....	....	7·00	1·25	·75	....	5·00	....	12 5 8†
Tomato Manure	25	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	3·50	....	....	10·00	1·50	1·25	12·75	....	8·00	11 19 8†
Do. No. 2	63	do.	do. do.	....	3·50	....	....	6·00	·75	·75	7·50	12·00	....	13 5 0†
Tobacco Manure No. 5	26	do.	do. do.	2·80		....	....	11·25	1·75	1·35	14·35	2·50	....	9 2 8†
Liquid Manure	50	Faulding's	F. H. Faulding & Co.	....	7·50	....	....	....	....	....	5·00	3·50§		3s. per pint bottle.
6.—SUPERPHOSPHATE AND COPPER.												Copper Oxide.		
Super. and Copper	7	Cresco	Cresco Fertiliser, Ltd.	....	....	....	...	13·00	2·50	1·50	17·00	1·25		8 3 10†
Super. and Copper Ore	28	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	12·30	2·00	1·50	15·80	1·60		7 8 11†

§As Caustic Potash. ‖Price at Works, Sydney.

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O)		Cash Price per ton on rails Works † or Perth.‡
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Super. and Copper Ore	44	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	12·30	2·00	1·50	15·80	1·60		7 8 11†
Super. and Copper No. 1	62	C.S.M.L.	do. do.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	8 10 4†
B.—ORGANIC.														
(*a*) *Animal Fertiliser.*														
Animal Fertiliser	3	State Abattoirs, Midland Junct.	State Abattoirs, Midland Junction	....	....	8·00	....	....	....	5·00	5·00	....	....	9 5 0†
Blood and Bone	2	DBG in diamond	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	6·00	....	....	8·00	4·00	12·00	....	....	10 12 6‖
Blood and Bone	4	Wyndham	Wyndham Freezing, Canning Meat Export Works	....	....	5·75	....	....	6·00	9·00	15·00	....	....	10 12 6‡
Do.	29	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	5·00	....	....	....	15·00	15·00	....	....	10 10 0†
Blood, Bone, and Offal	1	Riverstone	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	5·50	....	....	9·25	5·00	14·25	....	....	7 15 0‖
Blood and Bone	46	A. and A. Surprise	C. A. Kirkby & Son	....	....	5·50	....	....	4·00	10·00	14·00	....	....	14 5 0‡
Do.	47	Albany Freezing Work	West Australian Meat Export Works	....	....	6·00	....	....	....	....	12·00	....	....	10 0 0†
Do.	48	Eclipse	do. do.	....	....	6·00	....	....	....	12·00	12·00	....	....	10 9 3†
Do.	49	Robb's	do. do.	....	....	5·25	....	....	....	14·00	14·00	....	....	10 4 3†
Do.	54	Apollo	J. Kitchen & Son Pty., Ltd.	....	....	7·00	....	....	9·00	5·00	14·00	....	....	*
(*b*) *Dried Blood*—														
Dried Blood	17	Cresco	Cresco Fertilisers, Ltd.	....	....	10·50	....	....	....	1·50	1·50	....	....	13 0 0†
(*c*) *Miscellaneous*—														
Garden Manure	56	Sprout-Em	Kag Manufacturing Co.	....	....	....	5·00	....	5·00	4·00	9·00	....	....	Sold in Packets*
Garden Fertiliser	58	Superhumus	Drake & Homer	....	2·00	....	....	1·80	·50	·20	2·50	2·00	....	6d. per lb.
Do. do.	64	Summit Growth Fertiliser Tablets	L. M. McLeod	....	4·10	....	....	7·00	1·20	·10	8·30	12 20	....	1s. per box retail

*Price on application. §As Caustic Potash. ‖Price at Works, Sydney.

Western Australia

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